Southern Interior Region Pest Management Plan for the Forest Health Program

Southern Interior Region, including
Cascades District
Kamloops District
Okanagan Shuswap District
Columbia District
Kootenay Lake District
Rocky Mountain District
Arrow Boundary District
Central Cariboo District
Chilcotin District
Quesnel District
100 Mile District
Quesnel District, and
Chilliwack District

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1.0 SUMMARY OF THE SOUTHERN INTERIOR REGION PMP FOR FOREST HEALTH

Term of PMP: effective May 1, 2008 and ending July 31, 2012.

Area of coverage: The Southern Interior Forest Region and eastern sections of the Chilliwack Forest District in the Coastal Region.

PMP Sections: defoliator management; bark beetle management; and other pest issues.

Notification of completion of this PMP, consultation and public review will be given to the Administrator, Ministry of Environment, Environmental Protection.

The Ministry of Forests & Range, Southern Interior Region has developed a Pest Management Plan (PMP) for the period commencing on May 1, 2008 and ending on July 31, 2012. The mandate of this PMP is to implement a proactive program of Integrated Pest Management that involves the identification, prevention, monitoring and control of various defoliating insects and bark beetles throughout the Southern Interior Region (SIR). The containment, control and mitigation of various forest insect pests will be conducted with the primary objective of preserving biological diversity, wildlife habitat, range forage, and a healthy and productive forest that can be enjoyed and used by the public. This Pest Management Plan has been prepared by the SIR Forest Health Program staff as required by the Integrated Pest Management Act and Regulation, B.C. Ministry of Environment, Environmental Protection.

The Southern Interior Forest Region (SIR) is comprised of the Cariboo, Kamloops, east and west Kootenay areas. The Southern Interior Regional Office is located in Kamloops, B.C. and there are two regional Service Centres located in Nelson and Williams Lake, respectively. The SIR has 12 Districts with 10 Satellite offices. The SIR covers 25M hectares, approximately 60% in productive forest land. The annual AAC of 32,400,000 m³ is approximately 37.9% of the provincial total. There are 86 First Nation Bands and Tribal Councils. The most significant pest affecting the forests in the SIR is the mountain pine beetle, currently affecting 5.4M hectares (2007 aerial overview survey). This Pest Management Plan covers Crown land areas throughout the SIR (Fig. 1). The areas of defoliator management apply specifically to the following forest Districts: the Chilliwack District in the Coastal Region; Chilcotin, Central Cariboo, 100 Mile House, Kamloops, Cascades, Okanagan Shuswap, Columbia and potentially the Arrow Boundary in the SIR. The SIR ranges from the dry semi-desert of Kamloops, Lillooet and the south Okanagan, to the interior wet-belt of Sicamous and Salmon Arm and mountain ranges of the Rockies. Lodgepole pine and Douglas-fir forests, with mixes of interior spruce, sub-alpine fir, cedar and other conifer and deciduous species cover much of the land base. As a result of this diverse landscape, the SIR also has numerous forest health issues.

This Pest Management Plan can be divided into three sections: one section for defoliators; one section for bark beetle management; and, one section for other pests that affect the forests of the southern interior.

The bark beetle section of this PMP shall encompass all twelve (12) Forest District's within the Southern Interior Region, excluding Tree Farm Licenses (TFL's). Each Forest
District in the SIR has developed a Forest health Strategy that is updated annually and describes the preferred strategies and tactics for managing bark beetles and other forest health issues. These individual Forest Health Strategies can be obtained from Forest Health staff in the Districts. The District Forest Health Strategies outline strategic as well as treatment details for each Beetle Management Unit (BMU) within District boundaries.

Detailed pest management activities in this PMP are for 3 bark beetles and 3 defoliators:
1. the mountain pine beetle, *Dendroctonus ponderosae*
2. Douglas-fir beetle, *Dendroctonus pseudotsugae*
3. spruce beetle, *Dendroctonus rufipennis*
4. western spruce budworm, *Choristoneura occidentalis*
5. Douglas-fir tussock moth, *Orgyia pseudotsugata*, and
6. western hemlock looper, *Lambdina fiscellaria lugubrosa*.

Pest management treatments in the Forest Health Program include: the use of manual or mechanical treatments; biological pesticides; silvicultural treatments; and, semiochemicals (aggregation, anti-aggregation and disruption pheromones). Some of the various treatment methods are listed below:

<table>
<thead>
<tr>
<th>Semiochemical &amp; Pesticide Treatments</th>
<th>Manual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verbenone (anti-aggregation pheromone)</td>
<td>Single tree fall &amp; burn</td>
</tr>
<tr>
<td>MCH - 3-methyl-2-cyclohexen-1-one (anti-aggregation pheromone)</td>
<td>Single tree fall &amp; peel</td>
</tr>
<tr>
<td>Aggregation pheromones for bark beetles (various) for tree-baiting and mass trapping</td>
<td>Heli-assist pile &amp; burn</td>
</tr>
<tr>
<td>Sex/aggregation pheromones for defoliators (monitoring and/or mating disruption)</td>
<td>Single or group (patch) harvesting</td>
</tr>
<tr>
<td>Aerial spray - <em>Bacillus thuringiensis</em> var. <em>kurstaki</em> (<em>B.t.k.</em>)</td>
<td>Harvest -sanitation</td>
</tr>
<tr>
<td>NPV - Nuclear polyhedrosis virus (NPV)</td>
<td>Harvest -salvage</td>
</tr>
<tr>
<td>Research: emamectin benzoate (a semi-synthetic avermectin derivative); fipronil (a phenyl pyrazole); neem (azadirachtin).</td>
<td>Thinning, spacing, pruning, fertilization</td>
</tr>
<tr>
<td></td>
<td>Species diversity &amp; tree breeding</td>
</tr>
</tbody>
</table>
2.0 OVERVIEW OF PLAN

The Ministry of Forests & Range has pest management responsibilities in all areas of the Southern Interior Region. Objectives guiding this PMP are as follows:

- To allow for longer term planning and to deliver a timely, effective Forest Health program.
- To provide an open forum for public participation concerning PMP development and content.
- To promote the use of techniques that minimizes forest pest problems and reduces the need for and use of insecticides.
- To reduce the number of referrals to Government Agencies, First Nations, stakeholders and interested parties by establishing a clear decision making process that considers wildlife habitat, water and fishery, cultural, environmental and silvicultural values. A clear decision making process sets standards for treatments.
- To reduce the current and future probability of damage by bark beetles, defoliating insects and other insects and diseases.

The largest population centres in the SIR include Kamloops, Kelowna, Vernon, Penticton, Williams Lake, Quesnel, Nelson, Cranbrook and Revelstoke among many other smaller communities. The Okanagan area of the region is one of the fastest growing areas in the province with the regional population is expected to exceed 550,000
people by the year 2025. Kelowna currently has a population of about 107,000 and Kamloops about 93,000.

This Pest Management Plan is meant to provide a framework for the integrated pest management of bark beetles, defoliators and other pests conducted by the Ministry of Forests & Range within the SIR and eastern sections of the Coastal Region. The PMP is required so that the is able to use a variety of control tactics to reduce risks to the surrounding resources.

The long-term objective described within this PMP is the management of the host species to reduce and minimize pest damage. Manipulating stand attributes, such as density, structure, species composition and age, in an effort to make stands more resilient to pests will reduce mid- and long-term losses and promote better stewardship of our forest resource.

To accomplish this objective, an integrated approach will be taken that involves all aspects of forest management and planning.

### 2.1 Forest Cover

The area covered by the Pest Management Plan encompasses all forested Crown land in the Southern Interior Region (Fig. 1). It must be noted that many insect defoliators and bark beetles have very defined ranges or hosts therefore the potential area of treatment would also be confined to those specific, smaller geographic areas. The SIR is ecologically one of the most diverse Regions in the province, with arid grassland dominated landscapes in the Thompson and Okanagan basin, to glaciers and 2-3 meter diameter Old Growth cedar forests dominated by an understory of large ferns in the upper Adams and Kootenays. Coastal and Interior climate conditions meet along the eastern slopes of the Coast Ranges creating large transition zones with great biological diversity.

Natural disturbance regimes such as wildfires, disease and insect outbreaks have shaped the landscape throughout most of the interior, with fires commonly occurring throughout the hot dry Thompson and Okanagan valleys every 10-25 years. By contrast, some areas in the wet Columbia mountain areas have seen fire return rates of much longer intervals.

There are about 21 tree species in the region with Douglas-fir, lodgepole pine, Engelmann spruce, Subalpine fir, western red cedar and western hemlock as the most prevalent. Deciduous species, including trembling aspen (At), Black cottonwood (Ac) and Paper birch (Ep) are often found mixed in these stands and sometimes dominate early seral stages.

### 2.2 Primary Land Use

The primary land uses occurring on Crown land within the area covered by this PMP are timber harvesting, regeneration, traditional use, range and wildlife use and recreation use. The main purpose of the Forest Health Program is to monitor, maintain and improve the health, resilience and productivity of the forest land base while reducing unsalvaged losses caused by various insects, diseases and other damaging agents. The Forest Health Program conducts assessments of the impacts of damaging agents on the forest resource.
Part of the overall Forest Health Program, as covered in this PMP, is the judicial use of pesticides to achieve these land use goals.

### 2.3 Forest Insect Pests

The forest insect species that will be treated under this PMP are those considered damaging to forest management objectives. The key forest insects described in this plan are:

- a) the mountain pine beetle, *Dendroctonus ponderosae* (Hopkins);
- b) Douglas-fir beetle, *Dendroctonus pseudotsugae* (Hopkins);
- c) spruce beetle, *Dendroctonus rufipennis* (Kirby);
- d) western spruce budworm, *Choristoneura occidentalis* (Freeman); and
- e) Douglas-fir tussock moth, *Orgyia pseudotsugata* (McD.), and
- f) Western hemlock looper, *Lambdina fiscellaria lugubrosa* (Hulst)

### 2.4 Public Use

A network of main and secondary roads that access most harvested areas service the developed area under this PMP. As areas are developed for harvest, public access increases. All main forest service roads are accessible for use by the public and will have signage notifying of pesticide use at all main entry points prior to treatment.

During harvest planning, recreation values are considered and integrated into the planning process where required. Outdoor recreation is a principal focus year round in the SIR with fishing, hunting, hiking, rock climbing, skiing, snow shoeing and various motorised activities being carried out throughout the Region.

The Ministry of Forests & Range established many high value recreation sites and trails for public use throughout the PMP area (now managed by Min. of Tourism). To maintain public safety and the integrity of these sites, the occasional use of pesticides in or near these sites may be warranted. In the past, activities such fall & burn for bark beetles and aerial spraying with *Bacillus thuringiensis* var. *kurstaki* (*B.t.k.*) and NPV for western spruce budworm and Douglas-fir tussock moth, respectively, have been conducted in recreation areas or Parks.

### 2.5 History of Pest Management in the Southern Interior Region

**Bark Beetles**

The Southern Interior Region has a long history of bark beetle and defoliator management. Much of the pioneering research and operational treatments for bark beetle and defoliator management was conducted in this Region. Fig. 2 shows the area of mountain pine beetle red attack as mapped each year in the aerial overview survey.
Figure 2. History of mountain pine beetle mortality in the Southern Interior Region 2003-2007, as mapped in the annual aerial overview surveys (data).

The Douglas-fir beetle and spruce beetle periodically reach outbreak levels, killing localized expanses of fir and spruce. The SIR is currently experiencing increased incidence and severity of Douglas-fir beetle, particularly in stands also sustaining budworm defoliation. High levels of mortality have been mapped within the Chilcotin and Central Cariboo Districts. The first large-scale control effort in the Province using mass trapping techniques and anti-aggregation pheromones (MCH) was successfully conducted in the Okanagan Shuswap in 2000-2001 (Jeans-Williams et al. 2001). Since then, numerous trials utilizing MCH have been conducted in the Cariboo and other areas.

The chemical MCH (See MSDS in Appendix 1) is an anti-aggregation pheromone produced by the DFB and is used to signal incoming beetles that a target tree is reaching maximum beetle capacity. Release devices (bubblecaps) containing this chemical may prevent mass attack on trees when present in sufficient concentrations. MCH bubblecaps are produced by Phero Tech Inc. and are classified as an excluded pesticide. MCH is typically deployed at a rate of 75-112/ha. The objective of deploying MCH is to protect living trees in combination with the use of attractant tactics (e.g. trap trees, mass trapping) and harvesting of green attack.

Spruce beetle control has been largely dealt with by the use of conventional trap trees coupled with harvesting. MCH is also being tested for use on spruce beetle as a potential control technique.

The current MPB outbreak began in about 1996 in various locations throughout the SIR. District Forest Health Strategies, containing detailed action plans for bark beetle management, are updated annually and all forest licensees are partners in these plans. Most areas in the Kamloops and Cariboo areas are in Salvage mode but there still remain some Suppression units in the south and southeast, and special management areas along the BC-Alberta border. Licensees are now using these plans to direct prompt and economical salvage and regeneration of affected stands. Harvesting is the primary control activity coupled with pheromone baiting, fall & burn, peel & burn and heli-assist pile & burn.
Defoliators
The three major defoliating insects that are aggressively managed in this Region are the western spruce budworm, Douglas-fir tussock moth, and the western hemlock looper. The western spruce budworm is increasing throughout the Region (Fig. 3) particularly in the Kamloops and Cariboo areas. In 1987, a high of over 820,000 ha of defoliation were mapped in the aerial overview survey. In 2007, 760,000 ha of defoliation were mapped indicating that we could potentially surpass the high seen back in 1987. In addition, the budworm is expanding into areas where it has not previously been recorded.

The Southern Interior Region has a fully integrated management plan for western spruce budworm that includes direct control using a biological insecticide, *Bacillus thuringiensis* var. *kurstaki* (*B.t.k.*). Various formulations of *B.t.k.* have been used over the past 20 years (Table 1) and numerous research trials have been conducted to determine to most biologically effective, ecologically safe and cost effective techniques to reduce damage caused by the budworm. The Region has also supported research into the effect of *B.t.k.* on non-target Lepidoptera (Boulton and Maclauchlan 2001).

Since the inception of the Regions operational program in 1991, *B.t.k.* has been applied neat at 2.4 litres per ha (30 BIU/ha). Spray aircraft (rotary wing or fixed wing) are equipped with a spray system having a minimum of four (4) nozzles capable of delivering droplets in the range of 100-120 median micron diameter at a constant rate and pressure over an even, unbroken swath (e.g. AU 4000 micronaires). The spray contractor must have a contingency plan and necessary equipment for containment and mop-up of any spills that may occur over the duration of the project.

The Douglas-fir tussock moth is a very cyclical insect, reaching outbreak proportions every 8-10 years in some part of the SIR (Fig. 4). The last outbreak was in 1991-1993 and was centered in the Kamloops area, with small epicentres near Hedley and Vernon. There is a fully integrated detection and management system in place for the tussock moth.

![Figure 3. History (hectares defoliated) of western spruce budworm 2000-2007, as mapped in the aerial overview surveys.](image)

**Table 1.** History of *B.t.k.* treatment against defoliating insects in the Southern Interior Region (1987-2007). The *B.t.k.* was applied at 30 BIU per ha (2.4 litres/ha) unless under a Research Permit.
Year | Kamloops | Cariboo | Area treated (ha) | Product Name
--- | --- | --- | --- | ---
1987 | 890 | 0 | 890 | Thuricide
1988 | 467 | 0 | 467 | Thuricide
1989 | 550 | 0 | 550 | Dipel
1990 | 0 | 0 | 0 | 
1991 | 4,000 | 0 | 4,000 | Dipel 132
1992 | 35,918 | 0 | 35,918 | Foray 48B
1993 | 33,945 | 0 | 33,945 | Foray 48B
1994 | 14,695 | 0 | 14,695 | Foray 48B
1995 | 7,600 | 0 | 7,600 | Foray 48B & 76B
1996 | 0 | 0 | 0 | 
1997 | 3,660 | 12,960 | 16,620 | Foray 48B
1998 | 7,280 | 13,064 | 20,344 | Foray 48B
1999 | 8,031 | 13,464 | 21,495 | Foray 48B
2000 | 0 | 7,091 | 7,091 | Foray 48B
2001 | 9,804 | 16,979 | 26,783 | Foray 48B & 76B
2002 | 4,548 | 23,110 | 27,658 | Foray 48B & 76B
2003* | 10,015 | 22,139 | 32,154 | Thuricide 48LV, Foray 48B
2004 | 0 | 25,504 | 25,504 | Foray 48B
2005 | 2,387 | 28,030 | 30,417 | Foray 48B
2006 | 16,500 | 27,482 | 43,982 | Foray 48B
2007 | 21,021 | 36,274 | 57,295 | Foray 48B

Total | 181,311 | 226,097 | 309,923 | 

*sprayed western hemlock looper

Management of the Douglas-fir tussock moth involves yearly monitoring with pheromones to detect building populations, sequential egg mass surveys and control of incipient populations using the virus (nuclear polyhedrosis virus, NPV) or application of a biological insecticide (\textit{Bacillus thuringiensis} var. \textit{kurstaki}) to protect foliage. The first operational program integrating all aspects of this system was successfully implemented during the 1991-93 outbreak (Table 2). Annual trap collections over the past two years indicate that another outbreak of tussock moth is imminent. Sequential egg mass sampling in the fall of 2007 verified that numerous sites around Kamloops will suffer moderate to severe defoliation in 2008. Some of the areas include Heffley Creek, 6 Mile Ranch area, Beaton Road, Palmer-Forsythe Road, Robbins Range Road and Barnhartevale. Treatment with NPV is planned for the spring of 2008 in these areas.
Figure 4. History of Douglas-fir tussock moth outbreaks in the Kamloops Region showing relative intensity of each outbreak period in terms of defoliation/damage.

Table 2. Application dosage rates for Virtuss® and TM Biocontrol-1® (upper table) and area (ha) and treatment regime from 1991-1993.

<table>
<thead>
<tr>
<th>1991 treatment</th>
<th>1992 treatment</th>
<th>Ha treated</th>
<th>1993 treatment</th>
<th>Ha treated</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Virtuss®</td>
<td>Virtuss® - full strength (12.5 g/ha)</td>
<td>600</td>
<td>Virtuss® - full (12.5 g/ha)</td>
<td>208</td>
</tr>
<tr>
<td>Old Virtuss®</td>
<td>Virtuss® - Alternate swath</td>
<td>50</td>
<td>TM Bio-1® - full (4.5 g/ha)</td>
<td>252</td>
</tr>
</tbody>
</table>

2.6 Pesticides to be used

Pesticides to be used for bark beetle and defoliator management under this PMP are:

<table>
<thead>
<tr>
<th>Target Insect and Active ingredient</th>
<th>Trade Name(s)</th>
<th>PCP No.</th>
<th>Application Rates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spruce beetle</td>
<td>MCH</td>
<td>NA</td>
<td>75-112/ha</td>
</tr>
<tr>
<td>Mountain pine beetle</td>
<td>Verbenone</td>
<td>19466</td>
<td>100 pouches per ha</td>
</tr>
<tr>
<td>Douglas-fir beetle</td>
<td>MCH</td>
<td>NA</td>
<td>75-112/ha</td>
</tr>
<tr>
<td>Western spruce budworm</td>
<td>Bacillus thuringiensis var. kurstaki</td>
<td>Foray 48B, 24977</td>
<td>30 BIU/ha @ 2.4</td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>-----------------------</td>
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<td>------------</td>
</tr>
<tr>
<td></td>
<td>Thuricide 48LV or other</td>
<td>17980</td>
<td>litres/ha</td>
</tr>
<tr>
<td><strong>Douglas-fir tussock moth</strong></td>
<td>Virtuss TM-Biocontrol1</td>
<td>17786</td>
<td>12.5 g/ha</td>
</tr>
<tr>
<td></td>
<td></td>
<td>19293</td>
<td>8.3 g/ha</td>
</tr>
<tr>
<td><strong>Bacillus thuringiensis var. kurstaki</strong></td>
<td>Foray 48B, Thuricide 48LV or other</td>
<td>24977</td>
<td>30 BIU/ha @ 2.4 litres/ha</td>
</tr>
<tr>
<td></td>
<td></td>
<td>24164</td>
<td></td>
</tr>
<tr>
<td><strong>Western hemlock looper</strong></td>
<td>Foray 48B, Thuricide 48LV or other</td>
<td>24977</td>
<td>30 BIU/ha @ 2.4 litres/ha</td>
</tr>
<tr>
<td></td>
<td></td>
<td>24164</td>
<td></td>
</tr>
</tbody>
</table>

* Product information on registered virus formulations available for use on the Douglas-fir tussock moth (*Defoliator Management Guidebook*).

<table>
<thead>
<tr>
<th>Trade name</th>
<th>Produced by</th>
<th>inclusion bodies (PIBS)</th>
<th>(grams of product)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Virtuss®</td>
<td>Forest Post Management Institute, Canadian Forest Service, Sault St. Marie, Ontario</td>
<td>$2.0 \times 10^9$ g</td>
<td>12.5 g</td>
</tr>
<tr>
<td>TM Biocontrol-1®</td>
<td>USDA Forest Service, Portland, Oregon</td>
<td>$2.68 \times 10^9$ g</td>
<td>3.5–7.0 g</td>
</tr>
</tbody>
</table>

### 3.0 OTHER PROCESSES AND HIGHER LEVEL PLANS

This PMP is consistent with all legislation such as the Forest and Range Practices Act, and any associated operational plans or site specific prescriptions written for areas where operational treatments will occur. The Ministry of Forests & Range will adhere to the Forest and Range Practices Act, all of the Regulations of this Act and all other Federal and Provincial Legislation, which may apply.

Land use plans currently in place include the Kamloops, Okanagan, Cariboo Chilcotin, Revelstoke, Robson Valley, West Kootenay Boundary and East Kootenay Boundary LRMPs (Fig. 5). This Pest Management Plan and other activities undertaken by the MFR are subject to higher level plans.
An example of a completed Land Use Plan is the "The Kamloops Land and Resource Management Plan" that involves the Crown-land resources spanning Kamloops, Clearwater, Logan Lake, Ashcroft and Chase.

“The Okanagan-Shuswap Land and Resource Management Plan (LRMP)” is another approved strategic land use plan within the Province of British Columbia. The plan area is characterised by rapid population growth, a diversifying economy and unique environmental settings - resulting in a range of interests and potential expectations. In conjunction with other legislation, the plan sets an integrated overall strategic direction for the management of crown lands within the Okanagan/Shuswap (Okanagan TSA).

4.0 THE INTEGRATED PEST MANAGEMENT PROGRAM

Integrated Pest Management (IPM) is a pest control strategy that uses an array of complementary methods: natural predators and parasites, pest-resistant varieties, cultural practices, biological controls, various physical techniques, and the strategic use of pesticides. IPM is an ecological approach that can significantly reduce or eliminate the use of pesticides.
Techniques such as pheromone monitoring, stand and host species manipulation, biological control, single tree treatments, and/or chemical controls may be implemented. The SIR Forest Health Program fully embraces the concepts of IPM. Pesticides are a very minor part of biologically based management strategies for bark beetles, defoliators and other insect and diseases. Pesticides are used only after monitoring indicates they are needed according to established best management practices guidelines and decision matrices, and treatments are made with the goal of removing or reducing only the target organism. Pest control methods are selected and applied in an effective and economical manner that minimizes risks to human health, beneficial and non-target organisms, and the environment. IPM has become even more important with the repercussions of climate change becoming apparent in the changing dynamics of some of our native forest insect pests.

IPM is defined in the legislation to mean, “a decision making process that uses a combination of techniques to suppress pests and must include but is not limited to the following elements:

a) planning and managing ecosystems to prevent organisms from becoming pests;

b) identifying potential pest problems;

c) monitoring populations of pests and beneficial organisms, pest damage, and environmental conditions;

d) using injury thresholds making treatment decisions;

e) reducing pest populations to acceptable levels using strategies that include a combination of biological, physical, cultural, mechanical, behavioral, and chemical controls; and,

f) evaluating the effectiveness of treatments.

4.1 Prevention

Prevention strategies are the keystone to the Southern Interior Region Forest Health Program. Prevention strategies include a number of long- and short-term tactics directed at the host, landscape (ecosystem) and insect. Prevention strategies and tactics will not eliminate the occurrence of insect outbreaks but will lessen the extent, duration, spread and damage incurred when insect populations reach outbreak proportions.

Long-term strategies for bark beetles include, but are not limited to:

- Annual monitoring for insect activity and host damage (windthrow, breakage, drought stress, fire damage);
- Host species management;
- Creating age and species mosaics across the landscape;
- Application of silviculture treatments to lessen the susceptibility of trees and stands;
- Creating access into highly susceptible forests and landscape units;
- Create long-term plans for managing susceptible species; and
- Hazard rating all susceptible landscapes.
Strategies for managing bark beetles fall into 5 categories: prevention, suppression, holding, salvage and monitor (http://www.for.gov.bc.ca/hfp/bark_beetles/index.htm).

The Prevention strategy is applicable to large areas of uninfested or lightly infested forest with a moderate to high hazard rating. Prevention aims at reducing the susceptibility of a particular stand or at reducing its attractiveness to the beetles. The intent of the strategy is to reduce losses through manipulation of forest cover.

Prevention strategies also indicate that harvesting plans should be based on existing and future hazard and risk criteria. That is, stands with the highest hazard and closest to existing beetle populations centres (high risk), should be logged or modified on a priority basis. The overall strategy is to remove the susceptible host in an organized manner that will not create extensive and continuous stands of susceptible forest over the next rotation.

The ideal prevention strategy would be to pro-actively reduce the area of susceptible forest by actively targeting the harvest of the most susceptible stands. Preventive measures are rarely carried out as this implies that the beetle populations are in an endemic or very low stage. Unfortunately, age class distributions throughout the Province remain skewed to high proportions of older, highly susceptible age classes for both lodgepole pine, spruce and Douglas-fir. When weather conditions severely impact beetle survival (i.e., very cold winters coupled with wet, cool summers), bark beetle populations may be driven back to endemic levels and prevention activities should be initiated.

At the stand level, there is some research evidence showing lodgepole pine stand susceptibility is reduced by partial cutting. Thinning may create unfavourable micro-climates that reduce the success of beetle host selection and colonization. Conditions for partial cutting are very specific and this method is not widely applicable. In mixed stands, selective removal of susceptible pine or spruce can reduce stand susceptibility and remove potential sources of spot infestations.

Spruce beetle and Douglas-fir beetle outbreaks often begin in fresh, downed material. Prevention is achieved through prompt removal of blowdown and large diameter slash thereby eliminating potential breeding material. Cutblock design that minimizes the risk of windthrow on the block’s margins will also prevent potential infestation sources.

The remaining bark beetle management strategies fall into the suppression, holding, salvage or limited treatment categories. Short-term strategies/tactics for bark beetles include, but are not limited to:

- Annual detection (air and ground);
- Analyze historic occurrence of outbreaks and check these areas in more detail;
- Monitor windthrow events e.g. top breakage will stress PI and therefore could be attacked by MPB. These trees will not be detected as “red” because their tops have been broken off;
- Monitor windthrow events for building spruce beetle populations;
- Monitor annual and 5 year weather patterns to determine stress level of forests i.e. drought stress will make trees more susceptible to bark beetle attack;
- Monitor for Douglas-fir beetle populations post-fire in susceptible types; and
- Apply single tree treatments, harvest or apply MCH to small, building populations of beetles.

**Long-term strategies for defoliators include, but are not limited to:**

- host species management;
- create age and species mosaics across the landscape;
- silviculture treatments to lessen susceptibility of trees and stands;
- create long-term plans for managing susceptible species; and
- hazard rate all susceptible landscapes.

**Short-term tactics for defoliators include, but are not limited to:**

- annual detection (air and ground);
- conduct prediction sampling in historic outbreak areas;
- establish permanent population monitoring sites;
- monitor weather patterns to determine stress level of forests;
- biological insecticide treatments when threshold levels of damage/insects are reached.

### 4.2 Pest Identification

The British Columbia Ministry of Forests (Doliner and Borden 1984) defines the term pest as being; “any organism or damaging agent designated as detrimental to effective resource management”. For the purposes of this Pest Management Plan, the term pest refers to the three bark beetle species and two or three defoliator species (Table 3).

<table>
<thead>
<tr>
<th>Pest common name</th>
<th>Latin name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mountain pine beetle</td>
<td><em>Dendroctonus ponderosae</em> (Hopkins)</td>
</tr>
<tr>
<td>Douglas-fir beetle</td>
<td><em>Dendroctonus pseudotsugae</em> (Hopkins)</td>
</tr>
<tr>
<td>Spruce beetle</td>
<td><em>Dendroctonus rufipennis</em> (Kirby)</td>
</tr>
<tr>
<td>Western spruce budworm</td>
<td><em>Choristoneura occidentalis</em> (Freeman)</td>
</tr>
<tr>
<td>Douglas-fir tussock moth</td>
<td><em>Orgyia pseudotsugata</em> (McD.)</td>
</tr>
<tr>
<td>Western hemlock looper</td>
<td><em>Lambdina fiscellaria lugubrosa</em> (Hulst)</td>
</tr>
</tbody>
</table>

Refer to the Bark Beetle Management Guidebook and Defoliator Management Guidebook (http://www.for.gov.bc.ca/hfp/health/FHintro/gb.html) for complete descriptions of the insects listed in Table 3.

Detailed aerial surveys for Douglas-fir beetle and spruce beetle are conducted annually as necessary in June-July after the foliage of the previous year’s attack begins to change colour. Attack centres are generally mapped on a 1:50,000 scale that will provide Forest Managers with opportunity to plan additional surveys or treatments.
Annual aerial overview surveys to detect mountain pine beetle attack centres and other insects, including defoliators, is conducted annually in late July-August. Aerial overview surveys are done to the Provincial MFR standard and identify areas that may require a more detailed air or ground survey in order to develop appropriate management strategies (http://www.for.gov.bc.ca/hfp/health/overview/overview.htm).

### 4.3 Monitoring

Annual aerial overview surveys are done over the entire Region to identify new epicentres of beetle attack, wind throw, defoliation and other forest health issues. These overview surveys also allow the effectiveness of past treatments to be monitored. All pest occurrences are tracked using a GIS data base. Annual red:green ratio’s are determined for the mountain pine beetle and fir beetle to track population dynamics. Overwinter mortality estimates are conducted in March of each year to estimate the relative beetle risk.

Defoliator populations are monitored through the use of permanent monitoring sites. These sites can be one or a combination of the following:

- 6-trap clusters baited with pheromone;
- single trap stations (pheromone baited);
- egg mass sampling sites; and,
- tree beating sites.

There are also numerous permanent sample plots established throughout the Region to monitor treatment effects, long-term pest impacts and other pertinent stand and insect dynamics.

### 4.4 Treatment Thresholds

The mandate for this IPM program is to set clear, distinct and tangible thresholds that will assist in determining the level at which bark beetles and defoliators become “pests” and require treatments to control or reduce damage. See Bark Beetle Management and Defoliator Management Guidebooks and Region Bark Beetle Plan and Region Defoliator Management Plan.

**Bark Beetles**

Formalized treatment thresholds have been developed for some of the more aggressive treatment regimes prescribed in Suppression BMU’s. The threshold are based on the biology of the beetle in question. For example, in order to impact a mountain pine beetle population (cause its population to decline) at least 80% of the population must be killed. Inoperational terms this translates into at least 80% of all green attack trees must be treated. Since detection is based on red attack mapping, over 80% of the spots and/or polygons mapped must be addressd in order due to the complexity of the factors influencing treatment decisions. These factors include logistical, economic, political, and biological conditions that may favour or prevent treatments from occurring. The most important factor is the availability of funding for single tree treatments.
In general, single tree treatments are proposed where the efforts, combined with directed harvesting, are expected to suppress or contain beetle populations. Such areas are described in the district’s bark beetle management strategy through their assignment of strategies for their BMUs.

Two documents have been produced that describe and outline the B.C. Forest Health program and mandate. A Provincial Forest Health Strategy (www.for.gov.bc.ca/hfp/health) and Forest Health Program are guides as to how and when we manage various insect and disease issues. Continuity of management effort is necessary to ensure that the forest resource is adequately protected and investments are not wasted. Also, it is necessary to acknowledge where and when further management action would not be appropriate.

During years of growing bark beetle infestations, the usual rates of increase in the numbers of infested trees ranges from 2 to 5-fold and may be higher in extreme years. An important consequence of this behaviour is that successful suppression is not likely to be possible unless aggressive action is taken during the first few years of an outbreak. Areas where suppression is the main objective should be separated from other infestations by distance or topographic features. Similarly, suppression activities in larger outbreaks should be limited to the expanding edge of the outbreak with the objective of slowing the spread. These are the basic concepts on which the concept of Suppression (or Aggressive) management areas, the assigned strategies and tactics, and distribution of resources are based.

Zonation of the province into broad bark beetle management areas will allow for rational allocation of resources such that aggressive actions will be taken primarily in areas where management will have the greatest impact in reducing subsequent beetle expansion and loss. There is no need for zonation if aggressive management is applied at the outset of an outbreak. Zonation is only required when there are outbreaks where management will have no effect or where there are insufficient resources to apply management throughout an area. Broad management zones will be further broken down into specific Beetle Management Units (BMUs) to deal with specific area-based infestation characteristics and management objectives (Tables 4, 5).

There are 4 broad beetle management zones reflecting different levels of infestation and management effort. Management zones are based on the consideration of the following factors:

- Management objectives and non-timber values and considerations
- Host availability and other resource information
- Provincial status of infestations based on overview survey
- Infestation trends
- Existing or potential access

The number and size distribution of zones within a forest district or forest region will depend upon the current state of the infestation, susceptible host types remaining and resources available.
Broad zones are as follows:

- Suppression/Aggressive Management
- Holding/Containment (Directed Harvesting Priority)
- Salvage
- Monitor (these are usually areas with no susceptible host or are have some protected designation).

### A. Suppression/Aggressive Management Zone

It is biologically feasible and sensible to carry out aggressive management and suppression. Objectives are to treat at least 80% of currently infested areas within 1 year of detection and 100% of detected infestations within 2 years. Aggressive application of all treatment options to all infestations within a 2-year period can be expected to achieve a substantial reduction in infestation size and spread.

Typically, this zone is characterized by a few moderate patches of infestations and a high spot to patch ratio. Infestations are on the leading edge of expanding large outbreaks or are individual infestations. High amounts of moderate to high hazard stands remain uninfested.

### B. Monitor/Containment

It is biologically feasible to at least hold infestations static with vigorous directed harvesting and limited single tree treatments. The objective is to treat 50 to 80% of detected infestations within 1 year.

Primary management activity will be directed harvesting (large and small blocks) of currently infested stands; containment baiting would be utilized wherever appropriate. Only limited use of direct control methods such as single tree treatment would be contemplated.

### C. Salvage

Management action is expected to have minimal impact on beetle population intensification or spread; the infestation has outstripped management resources and management cannot make an impact on beetle. Infested stands receive the highest priority for harvesting if harvesting capacity is available. Therefore all areas of current attack will have a high priority if there is harvesting capacity available.

Typically, infestations within this zone would be at least 3 to 5 years old with more than 20% of susceptible stands infested as patch infestations. Less than 50% of infested patches can be treated or harvested within 2 years. Infested patches likely to be larger than average cut block size and large contiguous areas of mortality exist in the area.

Management activities would be restricted to salvage of dead material or harvesting of stands with high levels of green attack. Minimal or no single tree treatments or probing for green attack would be applied. Infested stands (based on levels of red attack) would receive priority for harvest.
**DEFOLIATORS**

The following criteria must be met when planning a control program for western spruce budworm. These general concepts can be applied to other insect defoliators with some species specific differences.

**Damage Criteria:** stand has suffered a minimum of 1-year defoliation and defoliation predictions are moderate to severe for the coming year. **Note:** this does not apply to the eruptive defoliators such as loopers and tussock moths.

**Insect Criteria:** populations are building/increasing and expanding in range.

**Recent defoliation history:** light to moderate defoliation has occurred for a minimum of one year, and typically two or more years, before treatment would be considered. Defoliation in the coming season is predicted to be moderate to severe and trees in the understory layers will incur high levels of damage (mortality and top-kill) if there is no intervention.

**Areas considered for treatment must meet one or more of the following factors:**
- stand is in a historic area of chronic budworm activity;
- located in a woodlot;
- high in-stand mortality of other tree species such as lodgepole or Ponderosa pines;
- silviculture investment, such as spacing, pruning, thinning;
- recent partial cutting;
- moderate to high density in L3 and L4 layers (understorey layers); and/or
- Douglas-fir dominated ecosystems such as the IDFxh and IDFdk. (e.g. ICH stands endure very short-lived outbreak cycles and trees rebound quickly, so do not warrant direct control efforts);
- must be in the Timber Harvest Land Base (THLB);
- evidence of Douglas-fir beetle activity (building or adjacent).

### 4.5 Treatment Options

The tables in this section outline the major treatments and influencing factors governing those treatments to be used by the Ministry of Forests & Range in its bark beetle management activities under this PMP. Table 6 lists the various treatment options for bark beetles and defoliators. Table 7 lists by treatment option the various application methods and information pertaining to their use and safety.

### 4.6 Treatment Selection
Considering the influencing factors, several treatments are eventually ruled out by going through the dichotomous key and asking critical, objective questions. Possible and suitable treatment options are then extrapolated for the site or stratum given the above site-specific factors and constraints. This Decision making key is an effective tool and provides the planning Forester with optimum treatment options. The key is not intended to replace or supersede a professional or specialists judgement.

Using western hemlock looper as an example, the following section describes the decision process involved in deciding on treatment to mitigate damage by this insect species.

**Western hemlock looper**

Short-term direct control measures are taken only when western hemlock looper (*Lambdina fiscellaria lugubrosa*) populations reach proportions that threaten stewardship goals. Long-term management strategies, however, can reduce the risk of defoliator damage as well as improve the health and productivity of forested ecosystems. There are five components to integrating the evaluation of stand, site and insect populations in order to create plans and prescriptions. The steps are:

1. landscape level hazard and risk assessment;
2. aerial and ground surveys to map and evaluate looper activity and determine stand susceptibility and risk;
3. annual monitoring; and
4. predictive sampling (predicts insect levels and subsequent damage in the coming season) to develop treatment prescriptions;
5. long- and short-term treatments (i.e. B.t.k. spray).

**Stand Susceptibility**

Hazard and risk, or stand susceptibility, assessments should be done to adequately address the current and potential impact and dynamics of the western hemlock looper in terms of stand and site ecology. The long-term impacts of allowing a western hemlock looper outbreak to run its course would be the loss of integral Mountain Caribou winter range, increases in unslavaged losses and areas that are of lower value to numerous resources.

Stand susceptibility provides some guidance as to what to expect on various sites and can be used to establish priorities for undertaking surveys, treatments, and for developing silviculture prescriptions. Factors that are considered, and that influence stand susceptibility, are:

- historic occurrence of western hemlock looper (Fig. 1)
- expected frequency and periodicity of outbreaks (about every 9-11 years in the interior)
- biogeoclimatic zones and subzones,
- species composition
- stand density
- stand structure (e.g. single *vs*. multiple canopy structure)
• elevation and aspect;
• tree vigor;
• age; and,
• site characteristics.

Short-term strategies: Biological and chemical control
Foliage protection and population reduction are both short-term strategies. Direct control should be considered when moderate to severe defoliation is predicted in a stand the following year and building populations are present. *B.t.k.* is registered for use against the western hemlock looper. Operational trials were conducted in 2003 within the Columbia Forest District to determine optimum spray timing and dosage rates to achieve desired objectives.

The use of biological insecticides has proven to be very successful as a management option for other defoliators and will greatly assist in the options available for managing western hemlock looper. Environmental impact due to the application of biological insecticides is minimal, and efficacy is high provided the insecticide is applied in a correct and timely fashion.

Priority areas for *B.t.k.* treatment
The following tables should be considered when planning a control program for western hemlock looper. Special management or stewardship considerations may have to be considered when making a decision whether to treat or not. For example, in the Columbia Forest District the need to protect critical Mountain Caribou habitat is the key reason for deciding to treat. Due to the high probability of extensive and heavy mortality occurring during outbreak periods, there is a need to protect Mountain Caribou habitat corridors.

<table>
<thead>
<tr>
<th>Parameters affecting stand susceptibility to western hemlock looper.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factor</td>
</tr>
<tr>
<td>Biogeoclimatic zone</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Species Composition</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Stand Density</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Stand Structure</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Age Class</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
Description of activities involved in a management program for western hemlock looper.

<table>
<thead>
<tr>
<th>Activity Description for Western hemlock looper</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Aerial overview survey - fixed-wing, covering entire region, mapping visible pest damage. Maps are digitized, copied and distributed to all districts and licensees.</td>
</tr>
<tr>
<td>2. Annually establish pheromone baited monitoring traps for WHL at historic permanent sampling sites throughout high hazard stands.</td>
</tr>
<tr>
<td>3. Annually conduct 3-tree beating samples at historic permanent sampling sites throughout high hazard stands.</td>
</tr>
<tr>
<td>4. About 2 years prior to anticipated outbreak, begin population sampling by conducting egg surveys and/or more detailed aerial surveys.</td>
</tr>
<tr>
<td>5. When defoliation is detected in annual aerial overview survey, egg sampling should be conducted at a landscape level in high hazard stands and/or in a more concentrated fashion if a direct control program is being considered.</td>
</tr>
<tr>
<td>6. Implement control program as per western spruce budworm. At this time, Foray 48B (B.t.k.) has a limited use permit for the western hemlock looper.</td>
</tr>
</tbody>
</table>
Table 4. Framework for showing factors considered when selecting management strategies or control objectives for mountain pine beetle strategic planning.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Prevention</th>
<th>Suppression</th>
<th>Sanitation</th>
<th>Salvage</th>
<th>Monitor (no control)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount of current infestations to treat</td>
<td>100%</td>
<td>80%</td>
<td>50-79%</td>
<td>33%</td>
<td>0%</td>
</tr>
<tr>
<td>Zones of Management</td>
<td>Aggressive management</td>
<td>Sanitation</td>
<td>Salvage/Limited Treatment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hazard class</td>
<td>Mod- high&lt;br&gt;(low, when adjacent to M/H)</td>
<td>Mod to high</td>
<td>Mod to high&lt;br&gt;Required (must within 2 yrs)</td>
<td>Mod to high&lt;br&gt;Planned within 5 year period</td>
<td>All (adjacency issues)</td>
</tr>
<tr>
<td>Risk class</td>
<td>Low (no beetles yet)</td>
<td>Mod. To high</td>
<td>Mod to high&lt;br&gt;Required</td>
<td>Low to mod&lt;br&gt;Planned within 5 year period</td>
<td>All&lt;br&gt;Not required, not available</td>
</tr>
<tr>
<td>Access (existing or potential)</td>
<td>Not required – access plans should be in progress&lt;br&gt;(low, when adjacent to M/H)</td>
<td>Required&lt;br&gt;Required</td>
<td>Required (must within 2 yrs)</td>
<td>Planned within 5 year period</td>
<td>Not required, not available</td>
</tr>
<tr>
<td>Status of infestation (based on overview surveys)</td>
<td>Uninfested or lightly infested&lt;br&gt;(low, when adjacent to M/H)</td>
<td>Incipient (pre-epidemic)</td>
<td>Chronically infested, larger outbreak areas</td>
<td>Extensive outbreaks</td>
<td>Irrelevant</td>
</tr>
<tr>
<td>Location of infestations within &amp; outside THLB</td>
<td>Within THLB</td>
<td>Within THLB</td>
<td>Within THLB&lt;br&gt;Inside or outside THLB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>r-values (rate of population increase)</td>
<td>N/A or positive&lt;br&gt;Zero, Population stable or increasing&lt;br&gt;N/A or any other combination</td>
<td>Positive, population increasing&lt;br&gt;Negative, Population decreasing or static</td>
<td>Zero, Population stable or increasing&lt;br&gt;Negative, Population decreasing or static</td>
<td>Extensive outbreaks&lt;br&gt;N/A or any other combination</td>
<td>Extensive outbreaks&lt;br&gt;N/A or any other combination</td>
</tr>
<tr>
<td>Green: red ratios</td>
<td>N/A no beetles&lt;br&gt;Highest (many:1)&lt;br&gt;Low (1: many)&lt;br&gt;Irrelevant</td>
<td>High (many:1)&lt;br&gt;Stable (1:1 to &gt;1:1)&lt;br&gt;Low (1: many)&lt;br&gt;Irrelevant</td>
<td>Stable (1:1 to &gt;1:1)&lt;br&gt;Outbreak ongoing for several years&lt;br&gt;Irrelevant</td>
<td>Stable (1:1 to &gt;1:1)&lt;br&gt;Outbreak ongoing for several years&lt;br&gt;Irrelevant</td>
<td>Extensive outbreaks&lt;br&gt;N/A or any other combination&lt;br&gt;Extensive outbreaks&lt;br&gt;N/A or any other combination</td>
</tr>
<tr>
<td>2-3 year infestation history and trends</td>
<td>No infestation or started within last 2 yrs&lt;br&gt;Ongoing for ≥3 yrs.&lt;br&gt;Outbreak ongoing for several years&lt;br&gt;Irrelevant</td>
<td>Started within last 3 yrs.&lt;br&gt;Ongoing for ≥3 yrs.&lt;br&gt;Outbreak ongoing for several years&lt;br&gt;Irrelevant</td>
<td>Started within last 3 yrs.&lt;br&gt;Ongoing for ≥3 yrs.&lt;br&gt;Outbreak ongoing for several years&lt;br&gt;Irrelevant</td>
<td>Started within last 3 yrs.&lt;br&gt;Ongoing for ≥3 yrs.&lt;br&gt;Outbreak ongoing for several years&lt;br&gt;Irrelevant</td>
<td>Extensive outbreaks&lt;br&gt;N/A or any other combination&lt;br&gt;Extensive outbreaks&lt;br&gt;N/A or any other combination</td>
</tr>
</tbody>
</table>
### MANAGEMENT STRATEGIES

<table>
<thead>
<tr>
<th>Factor</th>
<th>Prevention</th>
<th>Suppression</th>
<th>Sanitation</th>
<th>Salvage</th>
<th>Monitor (No control)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount of current infestations to treat</td>
<td>100%</td>
<td>80%</td>
<td>50-79%</td>
<td>33%</td>
<td>0%</td>
</tr>
<tr>
<td>Zones of Management</td>
<td>Aggressive management</td>
<td>Sanitation</td>
<td>Salvage/Limited Treatment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spot: patch ratio</td>
<td>No patch only some spots</td>
<td>High (0.6-1.0)</td>
<td>Low (0-0.4)</td>
<td>Irrelevant</td>
<td></td>
</tr>
<tr>
<td>Topography relief</td>
<td>Present</td>
<td>Present</td>
<td>Present</td>
<td>Not required</td>
<td>Not required</td>
</tr>
<tr>
<td>Population vigour &amp; over-winter survival estimates</td>
<td>N/A</td>
<td>High</td>
<td>High to moderate</td>
<td>Mod to low</td>
<td>Irrelevant</td>
</tr>
<tr>
<td>Timber resource values at risk</td>
<td>High</td>
<td>High</td>
<td>Mod to high</td>
<td>Mod.</td>
<td>Low</td>
</tr>
<tr>
<td>Other (non-timber) values at risk</td>
<td>High</td>
<td>High</td>
<td></td>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>Tenure/ ownership</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Wilderness, Parks etc.</td>
</tr>
</tbody>
</table>
Table 5. Framework for showing factors considered when selecting management strategies or control objectives for MPB strategic planning.

<table>
<thead>
<tr>
<th>FACTORS</th>
<th>MANAGEMENT STRATEGIES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Prevention</td>
</tr>
<tr>
<td>Detailed aerial surveys conducted yearly</td>
<td>Required</td>
</tr>
<tr>
<td>Adjacent BMU strategy selection</td>
<td>Suppression</td>
</tr>
<tr>
<td>Available harvesting power (ACC &amp; any approved uplift)</td>
<td>Not required</td>
</tr>
<tr>
<td>Other forest health factors</td>
<td>Caution with root rots (<em>Armillaria ostoyae</em>), Plidwarf mistletoe (<em>Arceuthobium americanum</em>) (STT)</td>
</tr>
<tr>
<td>Chance of success in achieving control of beetle</td>
<td>High</td>
</tr>
<tr>
<td>Change of success in achieving management objectives</td>
<td>Very Low</td>
</tr>
<tr>
<td>Resource availability</td>
<td>High</td>
</tr>
<tr>
<td>Duration of strategy</td>
<td>Long term</td>
</tr>
</tbody>
</table>
Table 6. List of available treatment options for mountain pine beetle, spruce beetle, Douglas-fir beetle, western spruce budworm, Douglas-fir tussock moth and western hemlock looper.

<table>
<thead>
<tr>
<th>Treatment Options</th>
<th>Bark beetles</th>
<th>Defoliators</th>
<th>Western spruce budworm</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mountain pine beetle</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Species or age conversion</td>
<td></td>
<td>Partial cutting or thinning stands</td>
<td></td>
</tr>
<tr>
<td>Single-tree or small patch extraction</td>
<td></td>
<td>Create species mixes</td>
<td></td>
</tr>
<tr>
<td>Conventional harvesting</td>
<td></td>
<td>Manage for resilient stand structure</td>
<td></td>
</tr>
<tr>
<td>Fall &amp; burn</td>
<td></td>
<td>Biological insecticide treatment (B.t.k.)</td>
<td></td>
</tr>
<tr>
<td>Fall &amp; peel</td>
<td></td>
<td>Monitor/no action</td>
<td></td>
</tr>
<tr>
<td>Monitor/no action</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Verbenone</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| **Spruce beetle**               |              |             |                        |
| Species or age conversion       |              | Partial cutting or thinning stands |
| Single-tree or small patch extraction |              | Create species mix |
| Conventional harvesting         |              | Biological insecticide treatment (NPV or B.t.k.) |
| Fall & burn (not often done for SB) |          | Mating disruption (research stage) |
| Fall & peel (not often done for SB) |          | Monitor/no action |
| Conventional trap trees         |              |             |                        |
| Monitor/no action               |              |             |                        |

| **Douglas-fir beetle**          |              |             |                        |
| Species or age conversion       |              | Manage for shorter rotations |
| Single-tree or small patch extraction |              | Priority harvest of high susceptibility stands |
| Conventional harvesting         |              | Manage for mixed species stands |
| Fall & burn (not often done for fir beetle) |          | Biological insecticide treatment (B.t.k.) |
| Conventional trap trees         |              | Monitor/no action |
| MCH                             |              |             |                        |
| Mass trapping                   |              |             |                        |
| Monitor/no action               |              |             |                        |

Table 7. Treatment options describing host insect and tree species, application methods and timing, equipment, cost efficacy and safety.

**Fall and Burn**

**Target pine, fir or spruce:**
- stems attacked in the current year and containing live brood

**Equipment Used and Application Method:**
- power saw for falling and bucking the attacked trees into manageable lengths
- ignition fuel like fire starter or petrogel mixed with gasoline for starting the burn piles

**Cost of Treatment/ Factors Influencing Costs:**
- $45-->$100 / tree

**Factors Influencing Costs:**
- access to treatment area
- terrain
- density, number of attacked trees per site
- number of sites per operating area
- tree diameter and height
## Treatment Efficacy
- is dependent on the stand susceptibility and beetle pressure
- will generally be planned as a holding tactic or “mop-up”
- delay time until harvest should be no more than two years
- must be evaluated annually

### Worker and Public Safety Considerations:
- workers:
  - overall generally accepted method of bark beetle control
- mitigation:
  - special worker training in avoidance of injury due to falling in a closed canopy
  - lifting injury risk
  - increased fire risk during early spring application, increasing risk

### Effect of Treatment on Soil Properties:
- litter removal in location of the tree burned only

### Effect of Treatment on Fisheries Resources:
- minimal effect on any reduction in thermal cover along sensitive streams as this will be a selective tree treatment
- retain appropriate buffer on critical streams as per current Policy and procedures

### Effect of Treatment on Wildlife and Habitat:
- minimal effect on any reduction in habitat as this will be a selective tree treatment

### Benefits of Treatment (Social and Environmental):
- no pesticide used equates to a high public acceptance
- provides regional employment
- treatment can be selective only targeting certain species

### Limitations:
- high cost associated with labour intensive treatment
- high level of supervision required

## Fall and Peel

### Target pine or spruce:
- stems attacked in the current year and containing live brood

### Equipment Used and Application Method:
- power saw for falling and bucking the attacked trees into manageable lengths. Wood wizard and hand draw axes used to remove the bark

### Cost of Treatment/ Factors Influencing Costs:
- $65-$120 / tree

### Factors Influencing Costs:
- access to treatment area
- terrain, trafficability
- density, number of attacked trees per site
- number of sites per operating area
- tree diameter and height

### Treatment Efficacy (How long will treatment be effective?)
- is dependent on the stand susceptibility and beetle pressure
- used when low snow condition or other factors prevent the falling and burning of attacked site
- will generally be planned as a holding tactic, or “mop-up”, until roads and operational blocks can be planned
- delay time until harvest should be no more than two years

### Worker and Public Safety Considerations:
workers:
- overall generally accepted method of bark beetle control

mitigation:
- special worker training in avoidance of injury due to falling in a closed canopy
- lifting

**Effect of Treatment on Soil Properties:**
- minor litter increase from bark and branches

**Effect of Treatment on Fisheries Resources:**
- minimal effect on any reduction in thermal cover along sensitive streams as this will be a selective tree treatment
- retain appropriate buffer on critical streams as per current Policy and procedures

**Effect of Treatment on Wildlife and Habitat:**
- minimal effect on any reduction in habitat as this will be a selective tree treatment

**Benefits of Treatment (Social and Environmental):**
- no pesticide used equates to a high public acceptance
- provides regional employment
- treatment can be selective only targeting certain species

**Limitations:**
- high cost associated with labour intensive treatment
- high level of supervision required

---

**Harvest**

**Target pine, fir or spruce:**
- stems attacked in the current year and containing live brood

**Equipment Used and Application Method:**
- power saw or production falling equipment
- skid equipment
- loading equipment
- hauling equipment

**Cost of Treatment/ Factors Influencing Costs:**
- $14-$30 / tree

**Factors Influencing Costs:**
- access to treatment area
- terrain, trafficability
- density, number of attacked trees / volume per site
- number of sites per operating area
- tree quality

**Treatment Efficacy (How long will treatment be effective?)**
- is dependent on the stand susceptibility and beetle pressure
- selective harvest will generally be planned as a holding tactic until adjacency concerns are met

**Worker and Public Safety Considerations:**

workers:
- overall generally accepted method of bark beetle control

mitigation:
- special worker training in avoidance of injury due to falling in a closed canopy may be an issue for selective harvest

**Effect of Treatment on Soil Properties:**
- compaction may be a risk for ground based skidding and summer harvest

**Effect of Treatment on Fisheries Resources:**
- minimal effect on any reduction in thermal cover along sensitive streams for selective tree treatment
- retain appropriate buffer on critical streams as per current Policy and procedures

**Effect of Treatment on Wildlife and Habitat:**
- minimal effect on any reduction in habitat for selective tree harvest

**Benefits of Treatment (Social and Environmental):**
- no pesticide used equates to a high public acceptance
- provides regional employment
- treatment can be selective only targeting certain species
- utilises fibre that would otherwise be destroyed

**Limitations:**
- high cost associated with aerial harvest systems

---

### Monitor / No Action

**Target pine, fir or spruce:**
- stems attacked in the current year and containing live brood

**Equipment Used and Application Method:**
- aerial survey
- ground surveys

**Cost of Treatment/ Factors Influencing Costs:**
- variable

**Factors Influencing Costs:**
- survey method chosen
- access to treatment area
- terrain, trafficability
- density, number of attacked trees per site
- number of sites per operating area

**Treatment Efficacy (How long will treatment be effective?)**
- no effect on local population however information keeps interested parties/agencies aware of potential population levels, spread or declines

**Worker and Public Safety Considerations:**
- generally accepted method of bark beetle management within Parks and Protected areas however may pose as a risk to adjacent susceptible forests

**Benefits of Treatment (Social and Environmental):**
- no pesticide used equates to a high public acceptance

---

### MCH

**Target Douglas-fir:**
Live, unattacked stems that are to be protected from attack by Douglas-fir beetle

**Equipment Used and Application Method:**
- Apply bubblecaps of MCH to trees (host or non-host) with staplegun
- Place bubblecaps on north face as high as possible

**Cost of Treatment/ Factors Influencing Costs:**
- $300/ha

**Factors Influencing Costs:**
- access to treatment area and number of sites
- terrain
- contractor costs
### Treatment Efficacy
- dependent on the stand susceptibility and beetle pressure
- determined by spatial placement of MCH and beetle attack centres
- must be evaluated annually

### Worker and Public Safety Considerations:
- workers:
  - very low worker risk
- mitigation:
  - worker training in bubblecap placement and handling of semiochemicals

### Effect of Treatment on Soil Properties:
- no effect

### Effect of Treatment on Fisheries Resources:
- Minimal to no effect

### Effect of Treatment on Wildlife and Habitat:
- Minimal effect on habitat of wildlife

### Benefits of Treatment (Social and Environmental):
- no pesticide used equates to a high public acceptance
- provides regional employment
- treatment can be selective only targeting certain species

### Limitations:
- moderate cost

These tables outline the major treatments and influencing factors governing those treatments to be used by the Ministry of Forests & Range in its defoliator management activities under this PMP.

### Aerial application of B.t.k.

#### Target Douglas-fir:
**Western spruce budworm**
- only stands with increasing (building) populations
- next season defoliation is predicted to be moderate or severe
- stands are at risk due to past (1-2 years of defoliation) stress from budworm defoliation
- stands receiving silviculture treatments such as spacing, thinning
- high risk stands (e.g. multi-structured) with history of budworm
- high priority areas

**Douglas-fir tussock moth**
- stands with an incipient outbreak of Douglas-fir tussock moth
- high risk stands where other tree species may have suffered mortality (e.g. Ponderosa pine killed by MPB)
- stands receiving silviculture treatments such as spacing, thinning
- areas where human health is at risk
- historic outbreak areas

#### Equipment Used and Application Method:
- aerial application using fixed or rotary wing aircraft (e.g. Ag Cats, Hiller 12E, Lama)
- equipped with spray booms having a minimum of 4 Beecomist or 4 A.U. 4000 micronair atomizers (or equivalent)

#### Cost of Treatment/ Factors Influencing Costs:
- $25/ha all found (B.t.k or virus., aircraft, sampling, planning)
### Factors Influencing Costs:
- treatment area (size and geographic location)
- terrain
- number of treatment blocks
- local economics

### Treatment Efficacy
- dependent on insect density, stand structure and tree phenology
- must be evaluated annually

### Worker and Public Safety Considerations:
**workers:**
- overall generally accepted method of defoliator management

**mitigation:**
- special worker training in aerial spray technology

### Effect of Treatment on Soil Properties:
- none

### Effect of Treatment on Fisheries Resources:
- no effect on streams or any water body
- can overspray small streams and waterbodies

### Effect of Treatment on Wildlife and Habitat:
- none

### Benefits of Treatment (Social and Environmental):
- biological treatment
- treatment is very specific (only Lepidoptera feeding at time of treatment)

### Limitations:
- must have qualified and experienced ground crew
- must have suitable weather conditions

---

### Aerial application of NPV

### Target Douglas-fir:
- only stands with building populations of Douglas-fir tussock moth (generally year 1 or 2 of outbreak)
- stands receiving silviculture treatments such as spacing, thinning
- high priority areas

### Equipment Used and Application Method:
- aerial application using fixed or rotary wing aircraft (e.g. Ag Cats, Hiller 12E, Lama)
- equipped with spray booms having a minimum of 4 Beecomist or flat fan nozzles each

### Cost of Treatment/ Factors Influencing Costs:
- $25 ha all found (virus, aircraft, sampling, planning)

### Factors Influencing Costs:
- treatment area (size and geographic location)
- terrain
- number of treatment blocks
- local economics

### Treatment Efficacy
- dependent on insect density, stand structure and tree phenology
Worker and Public Safety Considerations:

workers:
- overall generally accepted method of defoliator management

mitigation:
- special worker training in aerial spray technology and working with NPV

Effect of Treatment on Soil Properties:
- none

Effect of Treatment on Fisheries Resources:
- minimal effect on streams or water
- retain appropriate buffer on critical streams and water bodies as per current Policy and procedures

Effect of Treatment on Wildlife and Habitat:
- none

Benefits of Treatment (Social and Environmental):
- biological treatment
- treatment is very specific (only effective on *Orgyia* species)

Limitations:
- must have qualified and experienced ground crew
- must have suitable weather conditions

Population reduction versus foliage protection

Direct control strategies include population reduction and foliage protection. Foliage protection is the strategy most commonly adopted for budworm outbreaks in B.C. The aim is to reduce feeding damage in order to maintain tree vigour and resilience. Low levels of defoliation (1-2 years) are acceptable.

Population reduction can be applied to areas where little or no defoliation can be tolerated. This strategy is applied in the early stages of an outbreak, to reduce extremely high populations, thereby minimizing significant resource impacts.

Variation in the timing of direct control can achieve either foliage protection or population reduction. Higher insect mortality is achieved when later instars are targeted (5th or 6th), however more *B.t.k.* must be consumed per insect to achieve desired results, and thus more damage is incurred prior to treatment. Late instars are more open feeding, consume greater quantities of foliage, and are thus more likely to encounter and consume a lethal dose of *B.t.k.*

Typically, peak 4th instars are targeted to minimize defoliation. Timing to achieve good foliage protection is difficult due to differences in host phenology and insect phenology. Larvae remain feeding in buds until 4th instar, and are thus well protected from predators and the effects of a spray program. Larvae begin open feeding on the flushed shoots at about the 4th instar. Buds on overstorey trees should be >80% flushed prior to treatment and understorey trees should be close to 100% flushed.
# Bark Beetle and Defoliator Management Decision Tree

<table>
<thead>
<tr>
<th>Step</th>
<th>Identification of pest group</th>
<th>Go to</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Identification of pest group</td>
<td></td>
</tr>
<tr>
<td>a)</td>
<td>Bark beetle species</td>
<td>2.</td>
</tr>
<tr>
<td>b)</td>
<td>Defoliator species</td>
<td>6.</td>
</tr>
<tr>
<td>c)</td>
<td>Other insect group</td>
<td>No action</td>
</tr>
<tr>
<td>2.</td>
<td>Identification of bark beetle species</td>
<td></td>
</tr>
<tr>
<td>a)</td>
<td>Mountain pine beetle, spruce beetle, Douglas-fir beetle</td>
<td>3.</td>
</tr>
<tr>
<td>b)</td>
<td>Other bark beetle species</td>
<td>No pesticide treatment</td>
</tr>
<tr>
<td>3.</td>
<td>Identification of defoliator species</td>
<td></td>
</tr>
<tr>
<td>a)</td>
<td>Western spruce budworm, western hemlock looper, Douglas-fir tussock moth</td>
<td>7.</td>
</tr>
<tr>
<td>b)</td>
<td>Other defoliator species</td>
<td>No pesticide treatment currently in use.</td>
</tr>
<tr>
<td>4.</td>
<td>Land status</td>
<td></td>
</tr>
<tr>
<td>a)</td>
<td>Species on crown land</td>
<td>4.</td>
</tr>
<tr>
<td>b)</td>
<td>Species on other jurisdiction</td>
<td>Notify party and identify options/risks</td>
</tr>
<tr>
<td>5.</td>
<td>Water Resources</td>
<td></td>
</tr>
<tr>
<td>a)</td>
<td>Species is not found adjacent to or in a riparian zone, domestic water intake, wells or water body</td>
<td>5.</td>
</tr>
<tr>
<td>b)</td>
<td>Species is found adjacent to or in a riparian zone, domestic water intake, wells or water body</td>
<td>No buffers needed when spraying B.t.k. No pesticide shall be applied within 30 m of domestic water intake or wells</td>
</tr>
<tr>
<td>6.</td>
<td>Other considerations</td>
<td></td>
</tr>
<tr>
<td>a)</td>
<td>Infestation is within a known management zone that could potentially restrict insecticide usage. Considerations would include community watersheds, native food gathering sites, wildlife habitat requirements, or other values that require protecting</td>
<td>Use only cultural or manual treatment methods based upon species-specific treatment recommendations, or monitor/No action.</td>
</tr>
<tr>
<td>b)</td>
<td>No other considerations required.</td>
<td>Use any of cultural, manual or pesticide treatment methods based upon species-specific treatment recommendations.</td>
</tr>
</tbody>
</table>

**Higher potency B.t.k. formulations, increased dosage rates, or double application of lower potency formulations, may be considered in the following situations:**

- high larval densities early in the outbreak phase
• building phase of outbreak when the management objective is population reduction
• high value stands
• in multi-layered stands (high foliar biomass).

Defoliation history of trees and stands, combined with the predicted level of defoliation, influence which tactic will be implemented. Stands that have already sustained significant damage over 2 or more years (moderate to severe whole tree defoliation) should be managed under the foliage protection strategy. This will decrease further significant damage from occurring. If the population reduction strategy is applied in this situation, considerable damage could occur prior to the treatment being applied. Figure 13 in the Defoliator Management Guidebook provides guidance in selecting an appropriate strategy. Table 18 and Figures 14 through 17 in the Defoliator Management Guidebook describe the decision process for determining when and where to apply direct control measures (http://www.for.gov.bc.ca/hfp/health/FHintro/gb.html).

4.7 Post Treatment Evaluation

Post-treatment evaluations shall be conducted in one of the following ways, dependent upon target insect and treatment. Table 8 details the evaluation techniques for each treatment option.

Table 8. Listing of post-treatment evaluations conducted for each available insecticide treatment, by target insect species.

<table>
<thead>
<tr>
<th>Target insect</th>
<th>Treatment</th>
<th>Post-treatment evaluation</th>
</tr>
</thead>
</table>
| Douglas-fir beetle                   | MCH                        | ➢ Conduct in the fall following treatment  
|                                      |                            | ➢ Assess number of attacked trees in treatment area compared to area(s) not treated                                                                       |
| Western spruce budworm, western hemlock looper | Aerial spray of B.t.k. | ➢ Assess spray deposit cards within 1 hr of application (inside & outside block boundary)  
|                                      |                            | ➢ Spray deposit may also be assessed (when available) using the ADAM-ELISA kit technology. This provides estimates of spray deposit.  
|                                      |                            | ➢ Pre- and post spray larval sampling is conducted to estimate insect mortality (inside & outside blocks). Last post-spray conducted when >75% are pupae.  
|                                      |                            | ➢ Fettes defoliation estimate is conducted pre- and post-spray (when insects have pupated) from inside and outside spray blocks.  
|                                      |                            | ➢ level of defoliation mapped in the following year indicates whether the program was effective                                                           |
| Douglas-fir tussock moth             | NPV, or B.t.k.             | ➢ Assess spray deposit cards within 1 hr of application (inside & outside block boundary)                                                                |
Pre- and post spray larval sampling is conducted to estimate insect mortality (inside & outside blocks). Last post-spray conducted when >75% are pupae.

Fettes defoliation estimate is conducted pre- and post-spray (when insects have pupated) from inside and outside spray blocks.

The Post-Treatment Evaluation will be implemented in an effort to refine future management prescriptions and strategies and will determine the need for any immediate follow-up treatment. Bark beetle management efforts are evaluated annually as part of the review of BMU performance. BMU Performance measures are based on the district/region’s ability to meet the target goals for detection and treatment established for each BMU in the late fall each year.

5.0 ENVIRONMENTAL PROTECTION

5.1 Community Watersheds and Water Intakes

Community Watersheds
There are numerous Community Watersheds throughout the SIR. Any activities within or adjacent to Community watersheds during the term of this PMP will be described in the Notice of Intent for all interested parties.

Surface Water
A Pesticide Free Zone (PFZ) of 10 meters will be maintained from all bodies of surface water when applying chemical pesticides as per label instructions. Adequate buffer zones will be associated with PFZ’s to ensure integrity of surface water and riparian areas.

When applying biological insecticides such as B.t.k. no Pesticide Free Zones are required and small streams and/or water bodies can be over sprayed as per current Policy.

Wells and Intakes
A minimum 30 meter buffer will be maintained from all domestic water intakes and wells. This information is made available to applicators prior to treatment.

During the development of the Notice of Intent to treat each year, all domestic water intakes that are within one (1) kilometre of the proposed treatment area will be identified and mapped. Consultation with the holder of the domestic water source will take place, and efforts will be made to alleviate concerns, if any arise.

5.2 Fish and Wildlife Resources and Riparian Areas

The area encompassed within this PMP includes many significant fisheries values. To prevent contamination of water in fish bearing streams, chemical pesticides will not be applied to ditches that flow directly or indirectly into fish bearing systems. When spraying B.t.k. major streams will be mapped and avoided where possible. B.t.k. can be over sprayed small streams and water bodies as per current Policy.
The SIR has many important and diverse habitats for mammals, birds, amphibians and fish species. Wildlife shall be managed according to current and evolving biodiversity guidelines.

All wildlife values and critical habitats identified in any of the numerous forest stewardship planning processes, or through the consultation/referral process, shall be protected when carrying out treatments under this PMP.

5.3 Species Requiring Protection

Where “at risk” animal or plant species have been identified in higher level planning, they will be managed accordingly within the Forest Health Program. Specialists within the Region, Districts and other Ministries will be consulted to help identify some of these species as well as locations where they are to be managed in these areas.

6.0 OPERATIONAL PRACTICES – PMP CONTENT REQUIREMENTS

6.1 Qualification of Personnel

Ministry of Forests & Range personnel trained in Integrated Pest Management, entomology and licensed with the Professional Foresters Association of B.C. are responsible for the development and implementation of the Pest Management Plan.

The treatment of forest insect pests (bark beetles and defoliators) within the plan area is performed by MFR staff and/or contractor personnel possessing valid service licenses to conduct forest insect control treatment. All pesticide use shall be carried out by or under the direct supervision of an individual with a valid British Columbia pesticide applicator certificate in the forestry category.

“The Contractor shall provide the required number of certified Pesticide Applicators (forestry category) so as to comply with the worker/supervisor ratio required by the Integrated pest Management Program, Ministry of Environment. Copies of the certificates of all certified personnel must be provided to the Ministry Representative.”

“The Contractor’s project supervisor must be certified as a Pesticide Applicator, and must be familiar with the constraints and requirements of the Pesticide Use Permit(s) or approved Pest Management Plan.”

“The Contractor must possess a valid British Columbia pest Control Service Licence, and shall make a copy available for inspection upon request by the Ministry Representative or the Integrated Pest management Program, Ministry of Environment.”

6.2 Pesticide Handling Practices
6.2.1 Pesticide Transportation

The Transport of Dangerous Goods Act regulates the handling and transportation of poisonous substances that may include chemical insecticides. The Pesticide Control Act also specifies certain transport procedures. The following procedures are followed with respect to the transport of insecticides as part of the Southern Interior Region Forest Health Program:

- Pesticide to be transported in original, labelled container(s);
- Insecticide to be carried separately from food, safety gear and people;
- Spill equipment to be carried on vehicle near insecticide; and
- Appropriate documents and placards to be carried in or on vehicle during transport.

“The Contractor shall deliver to the project area(s) sufficient quantities of pesticide(s) (in factory sealed containers), additives and carrier (except water), as supplied or arranged by the Province, to treat the unit(s) specified in the contract.”

6.2.2 Insecticide Storage

Insecticides will be stored in accordance with the Pesticide Control Act Regulations; this includes storage at District and Region compounds in a secure, lockable room that is vented to the outside and accessible only to those with authority to do so. The storage is equipped with necessary spill equipment and first aid in the event of spill.

“The Contractor shall provide a means of securing equipment and supplies to prevent unauthorized access to the pesticide(s).”

6.2.3 Mixing and Loading Insecticides

All pesticides used under this PMP shall be mixed at designated mixing and filling stations. Requirements and procedures to be followed during the mixing and loading of pesticides:

- Wherever possible, the mixing/loading station should be located in the treatment area and a minimum of (100) metres away from any water body. The mixing site shall be selected so that it is on level ground, and situated so that if a spill does occur, run-off into water bodies will not occur.
- The minimum crew size for mixing and loading will be one (1) dedicated person, and other then that, crew size will dependent upon the size of the project (ha to be sprayed).
- All pesticide use will be recorded by the Project Supervisor at the end of each day.

The following table outlines the minimum safety equipment required by personnel performing various functions with regards to insecticide operations under this PMP.

<table>
<thead>
<tr>
<th>Method</th>
<th>Function</th>
<th>Safety Equipment (Minimum)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B.t.k. or NPV</td>
<td>Any</td>
<td>Clean coveralls and standard gear</td>
</tr>
</tbody>
</table>

- Each B.t.k. or NPV load shall be recorded once loaded into the spray aircraft. The record shall include:
a) PMP number
b) Contractor name, service licence and certification number
c) Date and time
d) Insecticide name, PCP Number and concentration
e) Volume of insecticide in litres

The helicopter/fixed-wing spray aircraft shall include the following specific parts and features:

a) Loading equipment with an accurate metering device, or the aircraft tank/hopper with a calibration as to provide a positive measure of the insecticide. Filler connections should be compatible with loading equipment.

b) Leak proof system with positive shut off device. Loading gate and discharge tube gate shall be tight closing.

c) Functional quick dump.

6.2.4 Container and Residual Insecticide Disposal

The responsibility of container disposal associated with any pesticide application program lies with the contractor. It is the contractors’ responsibility to rinse empty insecticide containers (according to product recommendations) and dispose of at appropriate sites if necessary or return to vendor. Any unused pesticide will be stored at an appropriate facility (e.g. refrigerated, secure) in the original container for future use. The responsibility of container disposal associated with the defoliator program lies with the Ministry of Forests & Range Project Supervisor.

6.2.5 Spill Response Plan

A pesticide spill kit will be carried in the MFR Project supervisor vehicle during defoliator spray programs and shall contain as a minimum the following articles:

- Instructions for spills
- Emergency telephone numbers
- Kitty litter (2-20 kg bags)
- Large plastic garbage bags (4)
- Shovels (2)
- Plastic tarp (10’X10’ minimum)
- Dustpan and shop brush
- Flagging and rope
- First aid kit
- Personal protective safety gear (rubber gloves, safety glasses)

Project supervisor will approve spill plan prior to commencement of pesticide treatment.

6.3 Boundary Marking Procedures

Aerial Spray Programs

If aerial application of insecticides (B.t.k. or NPV) is planned, rotary wing surveys will be conducted prior to final delineation of spray block boundaries. Spray blocks will be
mapped on appropriate scale maps, ortho-photographs or satellite photographs. Spray areas generally encompass all high priority areas ensuring that the highest insect density areas are covered thus reducing re-invasion by insects.

Spray block boundaries are generally delineated by using distinctive features such as:

- timber type changes;
- open range;
- height of land;
- rock outcrops;
- lakes and creeks;
- fence lines and roads; and,
- private land.

All spray aircraft now utilize GPS spray guidance systems, which has all but eliminated the need for on-the-ground block boundary marking. Block boundaries are created in Arc GIS and all spray aircraft use these spatial files to load GPS co-ordinates of spray block boundaries.

### 6.4 Equipment Maintenance and Calibration

#### B.t.k. and NPV Application

Equipment will be supplied by the contractor and be in good working condition. An inspection and calibration of spray apparatus will occur prior to commencement of aerial spray projects each year. A log will be submitted to the Project Supervisor at the conclusion of the project.

As an example, for B.t.k. application:

- Conventional boom lengths not exceeding 75% of the rotor diameter or total wingspan.
- Equipped with at least four (4) micronair nozzles, of appropriate type (AU4000), or equivalent, for a B.t.k. spray. The pumping system shall provide a constant pressure capable of distributing the insecticide in an even and unbroken swath at the specified rate(s). This equipment shall be capable of providing 80-120 micron volume median diameter droplet sizes.
- A pressure gauge mounted in such a location that it can be read from outside the aircraft during calibration operations.
- A spray boom should be mounted according to helicopter/fixed-wing aircraft or boom manufacturer's specifications, unless the Contractor can demonstrate that a different position of spray boom will give an equal or better spray pattern.
- Nozzles mounted on the spray boom should be oriented to give best droplet spectrum for the desired job. Angle of the nozzles shall be uniform across the boom.
- When installed, a spray boom shall be of continuous construction. The nozzles will be distributed evenly along the spray boom attached to a helicopter. For a fixed-wing aircraft the inboard section of the right hand boom may require additional nozzles to compensate for propeller effect.
6.5 Pesticide Treatment Signs

The Southern Interior Region, Forest Health Program, Ministry of Forests & Range commits to the following minimum standards for information on treatment signs:

Signs containing site-specific information with regards to treatment of each site shall be posted main and secondary access points to the treatment area. Signs will be posted prior to, and during, the treatment process. All Pesticide Treatment Signs will:

- be of a minimum size of 12 x 12 cm;
- be water resistant;
- be posted using nails or equivalent;
- include the title “INSECTICIDE USE NOTICE” or “PESTICIDE USE NOTICE” in capital letters not less than 2.0 cm tall; and
- contain the following:
  1. Date of Application
  2. Pesticide Trade Name
  3. Pesticide Common Name
  4. PMP Number
  5. Purpose of Treatment
  6. Method of application
  7. Ministry Office, Address, Contact Name and Phone Number

![Notice of Pesticide Application](image)

Figure 6. Notice of Pesticide Treatment sign for western spruce budworm, Southern Interior Region.

6.6 Weather Monitoring

For *B.t.k.* and NPV – on-site weather stations will be set up to monitor weather in order to minimize drift, and achieve maximum spray deposit efficacy.

Weather and timing of *B.t.k.* application must be carefully considered before spraying. Applications are usually done in early morning (4:30-9:00 am) when relative humidity is high (50-100% RH), temperatures are between 5-20°C, and winds are 0-8 km/h, with gusts not exceeding 15 km/h. The best time to apply *B.t.k.* is when larvae are actively
feeding. There should be no threat of heavy, continuous rain for at least 24 hours after spraying. Light rain, for short a duration will not seriously impact the efficacy of treatment. Heavy rains could wash off spray deposit, and similarly if foliage is wet at the time of application, spray droplets may not adhere to the foliage. As long as foliage is not wet to the point of run-off, some moisture in the stand is desirable, as it will maintain a higher humidity. Budworm larvae tend to feed more during warm weather; therefore it is advisable to spray at these times.

- An anemometer (wind speed), sling psychrometer (RH) and thermometer will be used at spray sites before and during spray operations to ensure weather conditions are suitable for insecticide application.

### 6.7 Pesticide Application Procedures

*Application techniques for B.t.k.*

Weather and timing of *B.t.k.* application must be carefully considered before spraying. Applications are done when the following parameters are met:

- relative humidity is 50–100%
- foliage is dry or damp but not wet
- heavy rain is not forecast in the next 24 hours
- temperatures are between 5–20°C
- winds are 0–8 km/h, with gusts not exceeding 15 km/h.

The best time to apply *B.t.k.* is when larvae are actively feeding. Budworm larvae tend to feed more during warm weather; therefore it is advisable to spray at these times. There should be no threat of heavy, continuous rain for at least 24 hours after spraying. Heavy rains could wash off spray deposit, and similarly, if foliage is wet at the time of application, spray droplets may not adhere to the foliage. Light rain, for a short duration will not seriously impact the efficacy of treatment. As long as foliage is not wet to the point of run-off, some moisture in the stand is desirable, as it will maintain a higher humidity.

Both aerial and ground application techniques are available for applying *B.t.k.* However, aerial application gives the best coverage, and is generally the most economical method for large, continuous areas of mature forests. Either fixed or rotary wing aircraft may be used in the application of *B.t.k.* Aircraft should be equipped with spray systems capable of delivering droplets in the range of 80–120 median micron diameter at a constant pressure over an even, unbroken swath.

Sample lines inside and outside of treatment areas can be established to assess the efficacy of *B.t.k.* treatments. Treated and untreated areas should have the same budworm population, cover the same elevational range, and have similar stand structure and composition.

Establishing sample lines for pre- and post-spray sampling:

1. Sample lines should be at right angles to the predicted spray swath, and cover the range of elevations within the treatment area.
2. Sample trees on sample lines should be a minimum of 50 m inside treatment boundaries and spaced about 50 m apart.
3. The number of sample trees is dependent upon the ultimate objective of the sampling (e.g. research project) and size of the project.

Application Techniques for Nucleopolyhedrosis Virus (NPV)
NPV should be applied as soon as tussock moth larvae hatch from egg masses and have moved to the foliage (usually in May). NPV is specific to native tussock moths found in B.C. Ground or air application of virus is feasible as the virus will spread (±50 metres) from the point of application within the first year via insect-to-insect contact. Aerial treatment is necessary when stands are large or not easily accessed. This is ideal for early treatment of incipient outbreaks a year before significant defoliation is expected. Treatment at the building phase of an outbreak will cause the population to collapse in strands treated. Therefore, no subsequent treatments will be necessary and no significant defoliation will occur.

Once visible defoliation is detected (year 1–3 of an outbreak), virus can still be applied causing a population collapse, but defoliation may be significant. In later stages of the outbreak cycle, other insecticides (e.g. B.t.k.) may be a better choice, as they will prevent further damage to the weakened trees, reduce possible allergic reactions, and lessen the chance of Douglas-fir bark beetle attacks. Application of NPV should occur when 80% of the larvae hatch from egg masses and have moved to the foliage. The virus is mixed as follows:
- 25% food-grade molasses
- 75% water (allow chlorine to evaporate for 24 hours)
- 10% of liquid weight Orzan® (Lignosite acts as a sunscreen).

Premix these ingredients the day before spraying, at staging sites near the treatment areas. Add the virus the morning of the treatment. Mix it thoroughly to remove lumps.

Use fixed or rotary wing aircraft, or truck-mounted spray systems to apply the virus mixture. Apply at 10 litres per ha, with a desired spray droplet diameter of 100–250 microns. To ensure good droplet deposition, spray during periods of low temperature, high humidity, and low wind velocity. NPV is only registered for use by the provincial or federal government.

6.8 Written Records
The Southern Interior Region, MFR, will retain forest health monitoring records as well as operational pesticide treatment records.

7.0 IMPLEMENTING THE PMP
7.1 Treatment Area Maps
Maps showing treatment areas will have clear legends and will be of sufficient quality, detail and scale to allow environmental risks to be assessed and to show the location of treatment sites. Two maps will be submitted.
1) A small scale, *overview* map showing the location of all sites, individually labelled, in relation to the entire PMP area.

2) A larger scale *treatment* map of the treatment areas showing:
   - Unit or block number
   - All major water bodies
   - Location of local roads, communities or recreation areas
   - Location of proposed treatments
   - Scale ±1:50,000

### 7.2 Notices of Intent to Treat

A copy of the “**Notification of Intent to Treat**” shall be posted each year at the appropriate Ministry of Forests & Range office to allow inspection by the public.

The Plan holder shall submit the “**Notification of Intent to Treat**” to the Deputy Administrator at least 45 days before the start of pesticide applications on site each year. The Notification will include:
- A notice, listing each site to be treated, and pesticide
- A treatment location map

A copy of the “Notification of Intent to Treat” shall be supplied to the Band Office of each affected First Nation when treatment is proposed within their traditional territory or area of interest by March 31st of each year or 45 days before the start of pesticide applications on site.

### 7.3 Advertising Treatment Sites

If required by the Deputy Administrator, additional advertising and notification requirements for particular treatments identified in “Notices of Intent to Treat” will be included in the PMP Approval document.

### 7.4 Annual Reporting

The Forest Health Program will submit annual summaries to the Deputy Administrator by December 31st in each year of the plan. For each site treated with pesticides within the PMP area during that calendar year, the report will list:
- PMP number
- site name, block number or description
- pesticide used, including PCP number
- method
- total area treated (ha)
- quantity of each active ingredient used (kg, litres)
- the total area treated with each pesticide (ha)
- for the entire PMP, the total quantity of each pesticide active ingredient used (kg)
- treatment location and/or map identifying areas of treatment.
8.0 TREATMENT PLANS FOR 2008

Western spruce budworm:
Estimated 65,000 ha to 70,000 ha of infestation planned for treatment with Foray 48B (B.t.k.) in 2008 to reduce impacts of western spruce budworm.

<table>
<thead>
<tr>
<th>Area</th>
<th>Estimated hectares to treat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cariboo</td>
<td>35,000 ha</td>
</tr>
<tr>
<td>Kamloops</td>
<td>30,000 ha</td>
</tr>
<tr>
<td>Coastal Region</td>
<td>3,200 ha</td>
</tr>
<tr>
<td><strong>Total estimated ha for treatment</strong></td>
<td><strong>68,200 ha</strong></td>
</tr>
</tbody>
</table>

The following maps show preliminary spray blocks/areas for the 2008 western spruce budworm spray program.
Proposed 2008 spray blocks in the Kamloops area
Proposed 2008 spray blocks in the Cariboo area
Proposed 2008 spray blocks in the Anderson/Siwash areas of the Coastal Forest Region
**Douglas-fir tussock moth:**
Estimated 5,000 ha of low elevation Douglas-fir forests in the Kamloops area identified as having incipient populations of Douglas-fir tussock moth will be treated with Virtuss (NPV) in 2008. The maps below indicate general areas where incipient populations have been found. Spray boundaries will be finalized later this spring.
9.0 GLOSSARY

allowable annual cut, (annual allowable cut) (AAC): The volume of wood that can be harvested in one year from an area of forest under a sustained yield management regime. The choice of AAC is based on knowledge of the potential fertility of the growing sites, the state and potential of stands currently growing, and assumptions about how existing and future stands will continue to grow.
**biodiversity**: The diversity of plants, animals and other living organisms in all their forms and levels of organisation and includes the diversity of genes, species and ecosystems as well as the evolutionary and functional processes that link them.

**biogeoclimatic ecosystem classification system (BEC)**: A hierarchical classification scheme with three levels of integration: regional, local and chronological. Coupled with this, BEC combines three classifications: climatic (or zonal), vegetation and site.

**biogeoclimatic subzone**: The second subdivision within the BEC framework. This subdivision is based on local climate conditions and has a distinct climax (or near-climax) plant association.

**biogeoclimatic zone**: The first subdivision within the BEC framework. This division is based on leading tree species in a climax state.

**buffer zone**: A strip of land between the Pesticide Free Zone (PFZ) and the pesticide treatment area. Chemical Pesticides are not applied directly in the buffer zone. The zone is established to prevent entry of chemical pesticides or pesticides residues by drift, runoff or leachate into the PFZ. This does not apply to *B.t.k.*

**ecosystem**: A complex system of living organisms (plants, animals, fungi and micro-organisms), together with their abiotic environment (soil, water, air and nutrients) that function together to circulate nutrients and create a flow of energy which creates biomass, a trophic structure in the living community and a change in ecosystem form and function over time.

**ephemeral stream**: Water body having defined channels but which flows for only part of the year, usually in spring and early summer.

**higher level plan**: An objective for a resource management zone, a landscape unit or sensitive area and/or a recreation trail or interpretative forest site usually consisting of a Forest Development Plan, Land and Resource Management Plan or a stand management plan (among others).

**integrated pest management**: A decision making process that uses a combination of techniques to suppress pests and that must include but is not limited to the following elements:

- planning and managing ecosystems to prevent organisms from becoming pests;
- identifying potential pest problems;
- monitoring populations of pests and beneficial organisms, pest damage and environmental conditions;
- using injury thresholds in making treatment decisions;
- reducing pest populations to acceptable levels using strategies that may include a combination of biological, physical, cultural, mechanical, behavioural and chemical controls; and
- evaluating the effectiveness of treatments.
**MCH:** The chemical MCH or 3-methyl-2-cyclohexen-1-one is an anti-aggregation pheromone produced by the Douglas-fir beetle (Ross and Daterman 1997).

**microsite:** A portion of a site that is uniform in micro-topography and surface soil materials. A microsite is the specific site occupied by an organism and the special relationship between this organism and its environment. Microsites are dynamic in that their characteristics are ever changing, imperceptibly or suddenly.

**no treatment zone:** An area that is reserved from treatment to meet a specific management objective.

**operating area:** A geographically defined area within the Forest District.

**pest:** Under the Pest Control Act, an injurious, noxious or troublesome living organism not including a virus, bacteria, fungus or internal parasite that exists on humans or animals; any organism or damaging agent designated as detrimental to effective resource management

**pest management plan:** as required by the Ministry Environment, Environmental Protection, a plan that describes:
(a) a program for controlling pests or reducing pest damage using integrated pest management, and
(b) the methods of handling, preparing, mixing, applying and otherwise using pesticides within the program.

**pesticide:** Under the Pesticide Control Act, an organism or material that is represented, sold, used or intended to be used to prevent, destroy, repel or mitigate a pest and includes:
(a) a plant growth regulator, plant defoliator or plant desiccant, and
(b) a control product, other that a device that is a control product under the Pest Control Products Act (Canada).

**pesticide free zone (PFZ):** An area around a specific feature that is to be free of pesticide. Pesticides may not be directly applied to, or allowed to reach the PFZ via drift, runoff or leachate.

**pesticide use permit (PUP):** Legally binding document approved and administered by the British Columbia Ministry Environment, Environmental Protection, which entitles a Licensee to carry out pesticide application on a particular area specified in that permit.

**red listed species:** Includes any indigenous species or subspecies (taxa) considered to be extirpated, endangered, or threatened in British Columbia. Extirpated taxa no longer exist in the wild in British Columbia, but do occur elsewhere. Endangered taxa are facing imminent extirpation or extinction. Threatened taxa are likely to become endangered if limiting factors are not reversed. Red-listed taxa include those that have been, or are being, evaluated for these designations

**silviculture prescription:** A site specific plan describing the nature and extent of the silviculture activities planned for a free growing stand of trees.
stakeholders: Registered trappers, guide outfitters, range use tenure holders and other affected members of the public who hold a vested interest in the management of the landbase being considered.

stratification: The process of defining and identifying populations with similar characteristics within an opening.

stream: A watercourse having an alluvial sediment bed, formed when water flows on a perennial or intermittent basis between continual definable stream banks.

water body: Water in a watercourse such as a river, stream or creek; water in the basin of a lake, marsh or slough; marine or estuarine water; water in a ditch that has the potential to discharge into fish bearing waters; water in an ephemeral stream; water accumulated in the holes formed by mounding, if the area with the water filled holes is greater than or equal to 35% of the total area mounded for the block or water accumulated in an area that has the potential to discharge into fish bearing water/habitat.

10.0 REFERENCES


Boulton, T.J. and L.E. Maclauchlan. 2001. Monitoring non-target Lepidoptera on Ribes cereum to indicate side effects of an operational B.t.k application.


## APPENDIX 1

### MATERIAL SAFETY DATA SHEET

**PHERO TECH INC.**  
7572 PROGRESS WAY  
DELTA, BC  
CANADA V4C 1E9  

**EMERGENCY NUMBERS**  
Canutec: (613) 996-6666  
Phero Tech: (604) 940-9944

### SECTION 1 - MATERIAL IDENTIFICATION

<table>
<thead>
<tr>
<th>PRODUCT NAME</th>
<th>FORMULA</th>
<th>SYNONYMS</th>
<th>CAS #:</th>
<th>FORMULA WT:</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCH</td>
<td>C7 H10 O</td>
<td>3-Methyl-2-cyclohexen-1-one</td>
<td>1193-18-6</td>
<td>110.17</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>UN #:</th>
<th>RTECS #:</th>
</tr>
</thead>
<tbody>
<tr>
<td>N/A</td>
<td>GW7340000</td>
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</tbody>
</table>

### SECTION 2 - COMPONENTS

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>% WW</th>
<th>CAS of UN#</th>
<th>TLV</th>
<th>HAZARD</th>
<th>LD₅₀/LC₅₀</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-Methyl-2-cyclohexenone</td>
<td>98</td>
<td>1193-18-6</td>
<td>N/A</td>
<td>Irritant</td>
<td>1600 mg/kg Mouse Oral</td>
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<tr>
<td>LV-5411</td>
<td>1</td>
<td>3147-75-9</td>
<td>N/A</td>
<td>Irritant</td>
<td>&gt;10000 mg/kg Rat Oral</td>
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Only selected RTECS data presented here. See actual entry for complete details.

### SECTION 3 - PHYSICAL DATA FOR MATERIAL

<table>
<thead>
<tr>
<th>APPEARANCE:</th>
<th>Colorless or light yellow liquid</th>
<th>SOLUBILITY IN WATER:</th>
<th>Insoluble</th>
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<tbody>
<tr>
<td>ODOR DESCRIPTION:</td>
<td>Characteristic</td>
<td>BOILING POINT:</td>
<td>150°C</td>
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<tr>
<td>VAPOR PRESSURE (20°C, mm Hg):</td>
<td>N/A</td>
<td>% VOLATILES:</td>
<td>99</td>
</tr>
<tr>
<td>VAPOR DENSITY (AIR = 1):</td>
<td>&gt;1</td>
<td>FREEZING POINT:</td>
<td>-21°C</td>
</tr>
<tr>
<td>SPECIFIC GRAVITY @ 25°C (WATER = 1):</td>
<td>0.969</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### SECTION 4 - FIRE & EXPLOSION HAZARD OF MATERIAL

| FLASH POINT (°C): | 71°C |
| EXTINGUISHING MEDIA: | CO₂, dry chemical powder, alcohol or polymer foam. If water must be used, it should be as a spray only |
| UNUSUAL FIRE & EXPLOSION HAZARD: | Vapours may form explosive mixtures with air. |
| HAZARDOUS COMBUSTION PRODUCTS: | CO₂, CO |

### SECTION 5 - REACTIVITY DATA

| FLAMMABLE LIMITS | LOWER EXPLOSION LIMIT: | N/A | UPPER EXPLOSION LIMIT: | N/A |
| SENSITIVE TO MECHANICAL IMPACT: | N/A |
| SENSITIVE TO STATIC DISCHARGE: | N/A |

| STABILITY: | Stable |
| CONDITIONS TO AVOID: | Sources of ignition |
| MATERIALS TO AVOID: | Strong oxidizing agents |
| HAZARDOUS POLYMERIZATION: | No |

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APPENDIX 2

**Mountain pine beetle, *Dendroctonus ponderosae***

The mountain pine beetle is the most devastating insect in British Columbia’s forests, killing vast tracks of lodgepole pine. Outbreaks occur about every 10-15 years in the Kamloops Region and can reach thousands of hectares in size.

**Host trees:** Its primary host is lodgepole pine, however in B.C. the MPB attacks ponderosa, western white and whitebark pines.

**Description and life cycle:** Adult mountain pine beetles are hard, stout-bodied, cylindrical, brown-black insects ranging in length from 3.5 to 6.5 mm. In general, the mountain pine beetle has a one year life cycle. Adults fly and attack susceptible trees in late July through August. Trees produce large amounts of resin toxic to the beetle when attack occurs. In order for insects to successfully overcome the defence mechanisms of a tree, large numbers of beetles must aggregate and attack within a very short time frame (mass attack). Attacking beetles introduce a blue stain fungus that combined with gallery construction kill the tree. Females initiate attack by burrowing under the bark and emitting a pheromone that attracts males. Once the tree is full of beetles, anti-aggregation pheromones are released thereby ceasing further attack.

After mating, females tunnel upwards and lay eggs on alternate sides of the gallery. When the eggs hatch the larvae mine out horizontally from the main gallery. Eggs hatch in 2 weeks and 1st instar larvae mine perpendicular to the parent gallery. The mountain pine beetle develops through 4 instars, overwintering as 3rd instar larvae.

Development is completed the following spring. Mature larvae excavate a chamber and pupation occurs in early to mid-summer. Pupae moult to immature (callow) adults. Beetles then feed on the blue stain fungi within the pupal chamber for up to 2 weeks prior to emerging. Finally, from mid to late July, mature beetles bore out of the bark and attack new hosts, thereby completing the cycle.

Attacked trees can be recognized by pitch tubes on the bole, frass and sawdust around the base, and red foliage the season following attack.
Douglas-fir beetle, *Dendroctonus pseudotsugae*

The Douglas-fir beetle is an important native pest in older Douglas-fir stands. Beetles frequently follow stand disturbances such as fire, wind or disease. Infestations are often associated with successive years of moderate to severe spruce budworm damage. Though commonly sporadic and short in duration, outbreaks are capable of killing large numbers of trees.

**Host trees:** Its primary host is Douglas-fir, however it will occasionally attack western larch. Trees attacked are most often felled, wind thrown, injured, diseased, or otherwise stressed.

**Description and life cycle:** Adult Douglas-fir beetles are robust, cylindrical insects that range in length from 4.4-7.0 mm. They are dark brown to black with black heads and reddish wing covers.

Typically, Douglas-fir beetles fly and attack susceptible trees in May and June. If conditions are favourable, some adults may re-emerge later in the summer to attack new trees and establish a second brood. Female beetles seek out Douglas-fir trees and burrow into the living tissue under the bark. They release pheromones that attracts male beetles and other females to the tree. After mating, the beetles excavate a vertical egg gallery, which runs parallel to the grain of the wood. Females lay about 50 eggs in small groups on alternate sides of the gallery. The eggs hatch into larvae which mine horizontally out from the main gallery. At the end of each mine larvae construct a chamber where they pupate and become adults. The brood overwinters as larvae or immature adults and in the spring mature adults emerge to attack new host trees.

Attack is noted by the presence of red-orange boring dust in the crevices of bark and at the base of attacked trees. Trees turn red in the spring following attack.
Spruce beetle, *Dendroctonus rufipennis*

The spruce beetle is a highly destructive pest of mature spruce trees and is found throughout the range of spruce in the Kamloops Region. Sporadic outbreaks have killed extensive stands of spruce in the province and usually last 5 or more years. Outbreaks often occur when beetle populations build up to high levels in downed material and move on to attack live, mature, large diameter standing spruce. The beetle prefers stands composed of more than 65% spruce occurring in well-drained creek bottoms.

**Host trees:** Hosts of the spruce bark beetle include Engelmann (interior), white, sitka and occasionally black spruce. Preferred host materials consist of weakened or windthrown trees, stumps and large slash. Blowdown occurs naturally, but increases along the edges of roads, utility right-of-ways, and logged areas.

**Description and life cycle:** The spruce beetle usually has a 2 year life cycle, but can vary from 1-3 years depending on geographic location, elevation and climatic conditions. Adults are hard, stout-bodied, cylindrical, black-reddish black insects ranging in length from 4.0-7.0mm.

In late May to early July, females initiate attack by boring into a host tree and releasing a pheromone that attracts both sexes and ensures mass attack. Eggs are laid in galleries that extend upwards from the entrance hole parallel to the grain of the wood. At first the larvae bore out horizontally in groups. When they are one third grown they then form individual mines which often intersect to form fan-shaped galleries. The brood overwinters as late instar larvae. The following spring to early summer they pupate and become adults. In late August many of these new adults bore out of the tree and crawl or drop to the base of the tree where they again bore under the bark to overwinter. Spruce beetles must overwinter once as adults prior to attacking new host trees. The overwintered adults emerge and attack fresh host material from late May to early July.

Infested trees have red brown boring dust present in bark crevices and around the base. Small pitch tubes may form where beetles attack. Woodpeckers may remove bark in search of larvae, exposing red patches on the tree. Spruce may fade a yellow-red but this is not always evident.
Western spruce budworm, *Choristoneura occidentalis*

The western spruce budworm is an important native defoliator of interior Douglas-fir. Outbreaks have been recorded in B.C. since the early 1900's to present in interior B.C. forests. Periodically, population levels reach outbreak proportions. In 1987, over 800,000 ha were under attack by the budworm, mostly in the southern interior of the province. Budworm outbreaks may be sustained for up to 25 years.

**Host trees:** Primarily Douglas-fir, with other tree species such as the true firs, larch and to a lesser degree, spruce, also impacted by the budworm.

**Description and life cycle:** Budworm moths mate and lay eggs in late July or August. The female deposits overlapping, shingle-like egg masses on the underside of Douglas-fir foliage. The egg masses are bright green when laid, and translucent white when empty. Larvae hatch but do not feed that summer and overwinter as 2nd instars. When buds begin to swell and burst the following summer, the insect emerges from their overwintering site and begins to mine buds. As they develop through six instars, the larvae become larger and feed more openly.

The greatest impact from budworm is among suppressed and intermediate trees. Repeated budworm defoliation causes tree mortality over large areas, reduction of growth rates and reduced lumber quality. Sustained attack results in complete defoliation in 4 to 5 years. Once an infestation has subsided, defoliated trees take several years to regain a full foliage complement, and therefore radial growth rates require several years to attain normal growth following defoliation by the budworm. Successive years of defoliation in stands may predispose trees to other insects and pathogens. Tree mortality may continue due to root disease, bark beetles, loss of vigour and other causes.
Douglas-fir tussock moth, *Orgyia pseudotsugata*

The Douglas-fir tussock moth is a destructive native defoliator of Douglas-fir. Outbreaks of tussock moth occur every ten to twelve years causing significant damage and mortality to Douglas-fir stands in the interior of the province. These outbreaks tend to last up to four years before natural controls such as predators, parasites, pathogens, and starvation lead to population collapse.

**Host trees:** Primarily Douglas-fir, occasionally ponderosa pine and western larch.

**Description and life cycle:** The tussock moth has a one year life cycle. Adults appear from late July to early September. The adult female is stout bodied, wingless and sedentary, usually remaining camouflaged on her cocoon. Males are slender bodied with about a 30 mm wingspan. Males emerge before females and fly in search of females. Females attract males by emitting a sex pheromone and mating occurs on the cocoon, typically, on the same day that the female emerges. Each female lays approximately 200 eggs in a single mass on her empty cocoon. The action of depositing her eggs dislodges hair from her abdomen which mixes with a frothy cement produced during oviposition. The egg masses overwinter. Larvae hatch in late spring and feed voraciously on the current year’s foliage. As the larvae mature, they feed on both old and new foliage. In late July the larvae pupate in cocoons on the underside of foliage and emerge two weeks later as adults to begin the cycle again.

**Damage symptoms:** The upper part of the crown and the branch tips are defoliated first. The remainder of the foliage is destroyed as the larvae migrate down the crown. By July, defoliated trees appear scorched. Trees may die after one or more years of severe defoliation. Frequently, the top third of the crown is completely defoliated, which leads to damage in the form of top-kill and branch dieback. Douglas-fir trees that have been weakened by tussock moth defoliation may also be susceptible to attack by other insect pests, such as the Douglas-fir beetle.
Western hemlock looper, *Lambdina fiscellaria lugubrosa*

The western hemlock looper is a native defoliator that is periodically destructive in coastal and interior forests of British Columbia. It reaches outbreak proportions every 11 in the interior and about every 20-plus years in coastal ecosystems. Western hemlock looper outbreaks usually last about 3 years and are generally brought under control by parasites, predators, and diseases (heavy rains during the moth flight period can reduce egg-laying & hasten the decline of an outbreak).

**Host Trees:** primarily where mature western hemlock predominates, but will readily feed on associated species in stands such as spruce, Douglas-fir and understory shrubs.

**Description and Life Cycle:** Moths fly, mate and lay eggs in late September-October. The eggs are about the size of a pinhead, blue to gray green or brown with a characteristic impression. They are attached to moss and lichen on tree boles and limbs and on moss in understory shrubs. Larvae hatch from eggs in the spring. Feeding by early instars during May, June and early July is light, and not too noticeable. Larvae are wasteful feeders, chewing off needles at their bases; thus causing the stand to appear yellowish-red then brown. Larger larvae feed voraciously on both old and new foliage and in heavy infestations trees may be stripped in a single season. In late summer, larvae are very mobile and feed voraciously. In August-September, caterpillars drop to the ground or lower branches to secret themselves in protected places where they pupate.

**Damage symptoms:** Defoliation in the interior occurs at 0-1400 m elevation and is found in valley bottoms having a high proportion of western hemlock. Defoliation often occurs in distinctive elevational bands with stands appearing yellowish-red, then brown, as if scorched by fire. Early defoliation occurs in upper crowns of trees; and progresses downward. The ground becomes littered with chewed needles and in severe outbreaks, the stand is covered in large amounts of silk-like webbing and loopers are seen hanging from branches. Trees can be killed after one year of severe defoliation (>50% foliage removed).